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FIELD DETECTION AND DAMAGE ASSESSMENT FOR OIL AND HAZARDOUS MATERIAL SPILLS

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FIELD DETECTION AND DAMAGE ASSESSMENT MANUAL FOR OIL AND HAZARDOUS MATERIAL SPILLS

ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF OIL AND HAZARDOUS MATERIALS

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FIELD DETECTION
AND
DAMAGE ASSESSMENT
MANUAL
FOR
OIL AND HAZARDOUS
MATERIAL SPILLS

ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF OIL AND HAZARDOUS MATERIALS
KENNETH E. BIGLANE, DIRECTOR

FIELD DETECTION
AND
DAMAGE ASSESSMENT MANUAL

Contract No. 68-01-0113

Submitted to: Environmental Protection Agency
Contracts Management Division
Washington, D. C. 20242

June 1972

FOREWORD

The Field Detection and Damage Assessment Manual was prepared by the Division of Oil and Hazardous Materials, Environmental Protection Agency, after months of planning and writing. With the exception of fish kills, the subject of damage assessment has not previously received systematic treatment. The objective was to prepare a guide for the preparation of damage assessment reports which will be complete in all respects and will fully meet scientific and legal requirements. The Dictionary of Hazardous Substances lists 226 materials and describes pertinent data under the headings of general properties, toxicity and detection. The initial phase of the Manual was developed using funds provided by the Office of Research and Development (OR&M). This is the first of a series of emergency response manuals. I also envision an ancillary Manual to catalogue computerized emergency technical information by means of an on-line retrievable terminal, safety manuals, and emergency spill response handbook as a reference for Federal staff and technical assistance.

Sincere gratitude is expressed to Dr. Allen [illegible] Jennings for his thorough review and revision of the sections dealing with the biological aspects of sampling and damage assessment. I also express appreciation to Mark F. Thompson for his review and editing, and to Bonnie J. Mattei for typing the major portions of the camera-ready copy.

As additional data and comments are received, appropriate corrections and additions will be made in this publication. Please address your written comments to Mr. J. Hugh Thompson, Chief, Hazardous Materials Branch, Office of Water Program Operations, Environmental Protection Agency, Washington, D. C. 20460.

Dr. J. Hugh Thompson
Chief
Hazardous Materials Branch

SUMMARY

The Manual is a field handbook for officials who are responsible for damage assessment after a spill of oil or hazardous polluting substances. It gives procedures and checklists for on-site use, with a dictionary of data about hazardous substances. Its objective is the production of damage assessment reports which are complete in all respects and fully meet legal and scientific requirements.

The dictionary can also be used by officials responsible for countermeasures, health and safety, clean-up, and restoration. In addition, the Manual provides guidelines for Federal and State officials involved in drawing up plans for damage assessment, instructions, standard procedures, and reporting forms.

The Manual is to be used before a field investigation, as a reminder of what will have to be done, during the investigation, as a guide to techniques and step-by-step procedures, and when reporting, as a checklist on completeness.

The Introduction describes how to use the Manual. Flow charts display steps in planning and investigation, and in identification of an unknown spill.

The chapters that follow begin with the initial site survey and planning of the investigation. The Manual refers to standard methods for detection and identification of a spill and for measurement of damage and gives rules for selection of sampling stations and schedules. A systematic method is recommended for applying the field data to quantitative damage assessment. To guide the investigation and reporting, sections of the Manual deal with statistical requirements, layman's rules for meeting legal requirements, and a checklist of details that should be in a full damage assessment report.

The Appendix is divided into three parts. Appendix A is a Dictionary of Hazardous Substances. The data are those useful in the field, such as general properties, toxicity in broad categories, and simple detection and identification tests. Appendix B is a cross index of well over a thousand synonyms and trade names. Appendix C is for use if the spilled substance has not been identified. It lists each hazardous substance against properties which should be readily observable on the initial survey, such as smell and color, so that the possibilities can be reduced to a small number.

INTRODUCTION

Purpose of Manual

This manual is primarily for use by Federal and State officials with on-site responsibility for field investigation of damage after a spill. It is directed to all members of the damage assessment team, and especially to the team leader.

The manual recommends procedures for applying established techniques to the specific task of damage assessment. These techniques are dealt with in detail in other publications. The user of the manual should be familiar with, and have the following available:

Methods for Chemical Analysis of Water and Wastes: EPA, 1971.

Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents: EPA, 1973.

Standard Methods for the Examination of Water and Wastewater: 13th edition, APHA, 1971.

A Practical Guide to Water Quality Studies of Streams: F. W. Kittrell; FWPCA, 1969.

The Practice of Water Pollution Biology: K. M. Mackenthun; FWPCA, 1969.

Investigating Fish Mortalities: K. M. Mackenthun, FWPCA, 1970.

Damage assessment, with the notable exception of fish kills, has not previously been treated as a systematic subject. Federal and other standard reference works, such as those quoted here, provide for the training and guidance of field investigators of water pollution, but there is nothing about sudden unpredictable spills, except in detailed reports of individual incidents.

Scope of Manual

The manual consists of seven chapters which deal with methods and procedures, and an appendix which is a compendium of data on hazardous materials.

Chapter 1:	SURVEY. Step-by-step instructions on what to do, from time of arrival until a full damage assessment plan is in operation.
Chapter 2:	CHEMICAL AND PHYSICAL EQUIPMENT AND TECHNIQUES FOR DETECTION AND IDENTIFICATION. What to use in locating a spill and making presumptive identification. The emphasis is on portability and simplicity, for qualitative and semi-quantitative analysis. Positive identification and quantitative analyses are not made in the field.
Chapter 3:	SAMPLING. General principles on what and where to sample, for use during planning and throughout the investigation.
Chapter 4:	BIOLOGICAL DAMAGE ASSESSMENT: EQUIPMENT AND TECHNIQUES. Similar to Chapter 2, but dealing with methods for biological investigation.
Chapter 5:	DAMAGE ASSESSMENT PROCEDURES. A systematic approach to the application of field investigations to damage assessment.
Chapter 6:	STATISTICS. Comment and guidelines on the use of statistics in the field, and the requirements for a damage assessment report.
Chapter 7:	REPORTING AND LEGAL REQUIREMENTS. A checklist of rules for meeting legal requirements, and of details to be included in a damage report.

APPENDIX B: DICTIONARY OF HAZARDOUS POLLUTING SUBSTANCES. Each page deals with a designated substance or closely related group of substances, in alphabetical order. Data are: chemical formula, synonyms, description, toxicity, precautions, and detection methods. The data are those useful in the field. For example, the description emphasizes readily observable properties, and toxicity is in qualitative terms.

APPENDIX C: CROSS INDEX. This is for use when the spill is known by name or by a group title. The index shows whether there is an entry under that name or whether reference should be made to another entry.

APPENDIX D: CATEGORIZATION OF HAZARDOUS POLLUTING SUBSTANCES. This is for use when the spill is not known by name. The substances in the Dictionary, Appendix B, are categorized by their readily observable properties, such as smell and color. The investigator matches his observations with these categories, and finds which substances fit [illegible] observations made. The spill may be one of these

How to Use the Manual

The manual has been organized to correlate as closely as possible with the sequence of work, from the first quick appraisal of the situation, through the development of a plan of action and conduct of the investigation, to writing of the damage report Each section is suitable for scanning before taking action, and as a checklist when planning, investigating, and reporting.

Planning

Planning must be developed in stages. The sequence is:

- Quick appraisal of the situation, to find what must be done at once or very soon.
- Preliminary plan of urgent action.
- Further, more detailed survey, to decide on the full scope of investigation.
- Final plan of full investigation.

The planning phase is detailed in Chapter 1 and shown in Flow Chart I.

If the spilled substance is known by name, use the Dictionary, Appendix A, for data about it.

When the nature of the spilled substance is not known, identification is urgently needed, to guide your plans and actions. Use the Dictionary, Appendix A, and Categorization, Appendix C, as indicated in Flow Chart III. The investigation is then conducted as for a known spill.

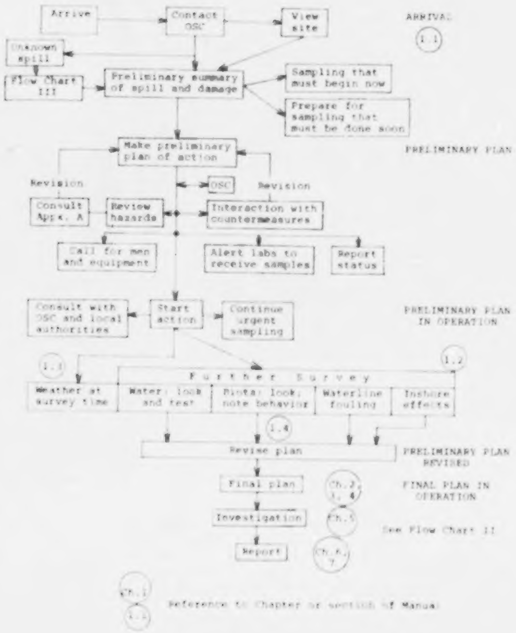
Use the guidelines in Chapters 2, 3 and 4 for selection of methods and sampling schedules while developing the plan. Refer to Chapter 7, Reporting and Legal Requirements, before finalizing the plan, to ensure that the investigation covers all possible requirements.

Investigation

This is shown in Flow Chart II, and guidelines are given in Chapter 5, Damage Assessment Procedures. Make further reference to Chapters 2, 3 and 4 for methods and sampling, and to Chapter 7 for legal requirements. Refer also to Chapter 6, Statistics, as soon as data begin to accumulate, use the recommended procedures to optimize sampling schedules, and make frequent preliminary evaluations of results.

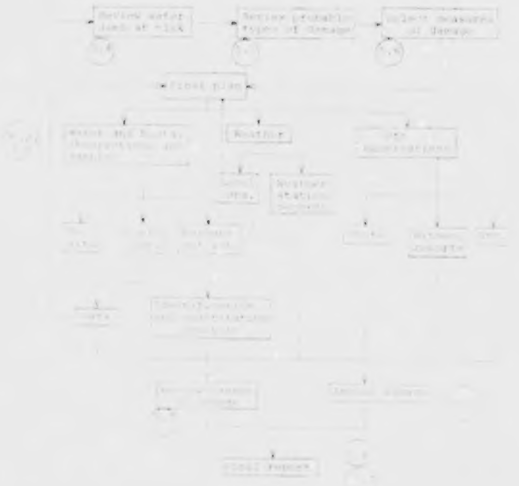
Reporting

Make final judgement on causes of damage, and assess damage in as quantitative terms as possible (Chapter 5). Prepare the report, referring again to Chapter 7.


Arrive
Contact OSC
View site
ARRIVAL
1.1
Unknown spill
Flow Chart III
Preliminary summary of spill and damage
Sampling that must begin now
Prepare for sampling that must be done soon
Make preliminary plan of action
PRELIMINARY PLAN
Revision
OSC
Revision
Consult App. A
Review hazards
Interaction with countermeasures
Call for men and equipment
Alert labs to receive samples
Report status
Consult with OSC and local authorities
Start action
Continue urgent sampling
PRELIMINARY PLAN IN OPERATION
1.3
1.2
Further Survey
Weather at survey time
Water: look and test
Biota: look; note behavior
Waterline fouling
Inshore effects
1.4
Revise plan
PRELIMINARY PLAN REVISED
Final plan
Ch.2, 3, 4
FINAL PLAN IN OPERATION
Investigation
Ch.5
See Flow Chart II
Report
Ch.6, 7
Ch.1
1.1
Reference to Chapter or section of Manual

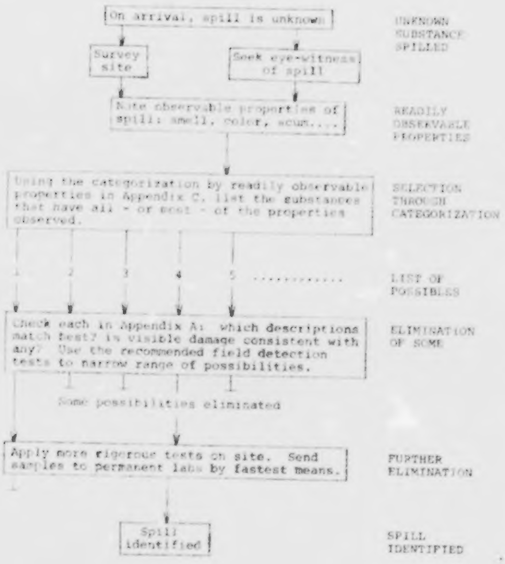
FLOW CHART I: PLANNING

From "Review plan"
in flow chart 1


Review water uses at risk
Review probable types of damage
Select measures of damage
Refine plan
Water and biota, observations and samples
Weather
Site examinations
Local obs.
Weather station records
Photos
Witness accounts
Identification and quantitative analysis
Final report

[illegible]

[illegible]


On arrival, spill is unknown
UNKNOWN SUBSTANCE SPILLED
Survey site
Seek eye-witness of spill
Note observable properties of spill: smell, color, scum....
READILY OBSERVABLE PROPERTIES
Using the categorization by readily observable properties in Appendix C, list the substances that have all - or most - of the properties observed.
SELECTION THROUGH CATEGORIZATION
1
2
3
4
5 ....
LIST OF POSSIBLES
Check each in Appendix A: which descriptions match best? is visible damage consistent with any? Use the recommended field detection tests to narrow range of possibilities.
ELIMINATION OF SOME
Some possibilities eliminated
Apply more rigorous tests on site. Send samples to permanent labs by fastest means.
FURTHER ELIMINATION
Spill identified
SPILL IDENTIFIED

FLOW CHART III: IDENTIFICATION OF UNKNOWN SPILL

CHAPTER 1

SURVEY

1.1 Introduction

The most urgent action on arrival at a site is to find whether there are any samples and observations that must be taken at once to avoid loss of valuable evidence. Next, make a quick survey of what has to be done, so that the necessary resources can be assembled.

The following actions cover the period from arrival to starting work on a damage assessment plan:

- Contact the On-Scene Coordinator (OSC).
- View the site.
- Assume that the damage assessment will be used in legal proceedings. (Review Chapter 7)
- Make a summary of available information about the spill: what was spilled, when, where, and how much. If the nature of the spilled material is not known, investigate at once. Use the categorization of hazardous polluting substances in Appendix C as a guide. Make sure there has been a spill.
- Make a summary of known and suspected damage.
- Determine if there is a threat of future damage, e.g., downstream.
- Decide what samples and observations must be taken as soon as possible.
- Begin this urgent sampling.
- Decide what samples and observations must be taken in the near future.
- Prepare for this sampling.
- Make a preliminary plan for full damage assessment. Things to consider are:

  Water uses damaged or threatened: municipal, industrial, agricultural, fish, wildlife, vessels, structures, foreshore, recreational uses and habitability for man.

Samples to take: water, fish, shrimp, etc., benthos, periphyton, plankton; plants, shoreline and inshore.

Records and witnesses needed: spill and its movement, damage and other effects; weather.

Discuss preliminary damage assessment plan with OSC.

Find whether countermeasures will affect damage assessment, or damage assessment interferes with countermeasures.

Discuss special hazards: toxicity, flammability, explosion potential, etc. (Consult the Dictionary, Appendix A.)

Modify the preliminary plan accordingly.

Set the plan in operation.

Call for men and equipment as required.

Alert central laboratories to which you expect to send samples.

Report status, according to standing instructions.

1.2 First Observations

The first observations made at the site influence the whole investigation. They can also be the most important part of the recorded evidence. Observe as much as you can personally.

Draw on local knowledge; a game warden or fisherman may best be able to see changes in a familiar environment. However, use this local help critically and under qualified supervision.

The following actions are usually the most important to take after the first quick survey. Think, however, about further special needs for each case.

Consult the OSC and local authorities for sources of local knowledge.

Survey the site. This is an extension of the quick viewing on arrival.

Note the appearance of the water.

Observe fish behavior: gasping, crowding, moribund, dead, absent.

Observe behavior and appearance of other vertebrates and of invertebrates.

Observe appearance of plants: fouled, [illegible] dead. Severely damaged vegetation may [illegible] dead for some time.

Record fouling of [illegible] and [illegible].

Be particularly alert for abnormal [illegible].

Look inshore for abnormal appearance of animals and plants.

Record the weather at the time of spill and survey: air and water temperature, precipitation, wind, sunshine.

1.3 Weather Observation

A record is needed from before the spill to the end of the investigation. The important factors are:

Air temperature: not less than 4 readings per 24 hours, preferably more.

Water temperature: not less than 4 readings per 24 hours, including early afternoon; preferably more. Take surface temperature, and subsurface temperature at one depth or more.

Precipitation: description, daily total, and note of abnormal intensity.

Wind: speed and direction, not less than 4 readings per 24 hours; more if movement of surface pollutant is important.

Sunshine: daily, in general terms (sunny, sunny intervals, etc.).

In tidal waters, schedule observations by tidal cycle and not the clock. Take readings at high and low tide (most important) and mid-flood and mid-ebb (less important). This applies particularly to water temperature and wind.

Take the following actions to get these records:

- Set up observations at the site if possible.
- Look for nearby official weather station: National Weather Service, military installation, Coast Guard, air pollution authority, etc. Ask for an expert opinion on the applicability of their records to the spill site.
- If there is no fully operational weather station nearby, seek a Cooperative Observer (name from National Weather Service), forest fire watcher, etc.
- In unsettled weather, always seek on-the-spot evidence. Locally heavy rain or high wind often miss all regular observing stations.

1.4 Planning Biological Sampling

Pay special attention to requirements for biological sampling, which is the major problem in damage assessment. Every site and incident is different.

Make decisions on:

- Live communities to sample: benthos, plankton, fish, etc.
- Moribund or dead samples to take: fish, crustacea, etc.
- Types of habitat to sample: riffle, pool, mud, various depths, etc. Since each has a different biota, sample all major types as a general rule.
- Size and disposition of sampling stations, and numbers of grab samples. These will probably have to be revised when some sampling results are available. As a general rule, take at least three samples each time at each station.
- Control samples: what and where.
- Water and sediment samples to be taken.
- Sequence for minimum disturbance of later samples: e.g., take water and plankton samples before disturbing the environment by use of dredges or grabs.
- Urgent sampling, such as dead fish which may be lost through water movement.

Give full weight to the wide seasonal variation in susceptability to damage of various parts of the ecosystem. This variation includes three components.

- Environment - Variation in quality of environment alters the importance of added pollution.
  Examples: a spill of high-BOD material is more serious if DO is seasonally (or diurnally) low; zinc is more toxic in the presence of copper. Increased temperature increases susceptibility of fish to degraded water quality; low DO similarly increases susceptibility.

- Community - Life cycles of residents and movements of migratory species modify the composition of the community at risk.
  Examples: immature organisms may be more sensitive than adults; specific populations may be present or absent depending on the season.

- Individual organisms - Some species are more susceptable than others.

CHAPTER 2

CHEMICAL AND PHYSICAL EQUIPMENT
AND TECHNIQUES FOR DETECTION
AND IDENTIFICATION

2.1 Introduction

This chapter deals with methods for use on site, in support of a damage investigation. There are two applications:

Detection, for locating a spill and tracking its spread.

Identification, for what damage to expect and interpretation of observed damage.

These require only qualitative and semi-quantitative tests. A fully equipped permanent laboratory must make all positive identifications and quantitative analyses quoted in the damage report.

The methods are convenient for use at the spill zone or in mobile or improvised facilities nearby. They are mainly for water sampling and also include sampling of ground, vegetation, etc. for spilled material.

Detailed procedures are not given. For these, the user must refer to standard works such as *Methods for Chemical Analysis of Water and Wastes* (EPA, 1974), and *Standard Methods for the Examination of Water and Wastewater* (APHA, 1971), which should always be on hand.

2.2 Sampling Procedures

Consider conditions before selecting procedures: what is to be tested for, how soon, by what method, etc.

Refer to the standard texts above and to ASTM Spec. Tech. Publ. No. 148-I and USGS Water Supply Paper No. 1454.

Select samplers to suit proposed analysis: e.g., avoid metallic construction for metal analyses, avoid unapproved plastic for PCB analyses.

Rinse samplers and sample bottles with the water to be tested.

Refer to Chapter 3 for guidance on sampling locations and schedules.

Sample surface film by partly submerged wide mouth bottle or the "dustpan" technique.

- Take sediment samples even if there is no immediate evidence of bottom contamination.
- Look for spill material at waterline and inshore. Scrape structures, take vegetation samples, mud samples, etc.

2.3 Sample Preparation

- Clear turbid samples by filter or centrifuge before tests for precipitation or color change.
- Do not, however, omit to test the removed solids, on which the spill may be bound physically or chemically.
- Treat suspended organic matter by acid oxidation if low concentrations of metals are sought.

2.4 Sample Preservation

- Always test samples as soon as possible. Some tests must be done at once (temperature, pH), others may be delayed.
- Use preservative measures whenever appropriate.
- Record preservative measures, and elapsed time from sampling to test.
- Test preservative before use, if it could upset results—e.g., test acids for trace metals.
- Dark and cool storage is usually beneficial.
- Acidify samples for metal analysis at once with nitric or hydrochloric acid, 5 ml per liter.
- Inhibit microflora in biodegradable samples: refrigerate, and use an appropriate preservative.
- Ensure that sample containers and closures will not alter the sample by adding trace metal, absorbing pollutant, etc.

2.5 Selection of Test Method

- Simplicity, convenience and speed of results are usually much more important than refinement of technique.
- Use a commercial detector or kit whenever possible. Examples include test paper or portable meter for pH, portable DO meter, and kits for specific metallic ions and families of organic compounds.

- Vapor detectors may be unsuccessful because of low vapor concentration and interference by water vapor and other volatile matter.

- Do not expect manufacturer's claimed sensitivities in the field. They apply to samples of "pure" material or water, not to samples of mixtures in a polluted environment.

- Wet-chemical tests are recommended for many substances in Appendix A. They are generally more prone to background interference than the kits.

- Cross-check identifications made by kit or wet-chemical test whenever possible.

- Use more complex instruments if necessary, in a mobile or improvised facility. Three are of wide usefulness: gas chromatograph (GC), visible-UV spectroscope (UV), atomic absorption spectroscope (AA), and infrared spectroscope (IR).

- Select GC column (support and liquid phase) with due consideration to substance looked for and to presence of water.

- Select GC detector for the intended purpose. Thermal conductivity is widely applicable but less sensitive (10^{-4} to 10^{-5} grams). Hydrogen flame and electron capture are more sensitive (10^{-6} to 10^{-9} gram) and fairly specific to hydrocarbons and polar compounds respectively.

- A heated column is desirable.

- Check GC identification with a similar reference sample if possible.

- UV absorption spectra give some separation or simple aliphatics (200 to 250 millimicrons) from higher aromatics (300 to 400 millimicrons), and may give specific identification (e.g., acridine).

- AA is good for most metallic ions, at sensitivities of 10^{-5} to 10^{-6} grams or better.

- Be alert for background interference at these high sensitivities.

- IR is the most versatile for identification of organic materials. Sample extraction may be required to reduce interference by water.

2.6 Checklist of Equipment

The following is a checklist of equipment that is generally useful in the field. It should be modified by local circumstances and individual preference. Use it as a guide to what should be drawn from a wider range at the base stockroom to investigate an unknown spill. A known spill requires less. Use it as a basic list for equipping a stand-by vehicle.

General equipment

Water sampler, sediment sampler, scraper, trowel.

Sample containers, labels.

Ice chest, chemical preservatives.

Reference texts: Appendix A, references in 2.1 above, etc.

Glassware.

Butane burner or similar.

Filtering apparatus and papers, and/or hand centrifuge.

Thermometers and portable temperature probe.

pH test papers and portable meter.

Portable DO meter.

Distilled water.

Kits

About half of the designated hazardous polluting substances can be adequately detected by one or more of the full range of commercial kits, such as those supplied by Hach, Kitagawa, MSA, and Scott-Davis.

Keep a comprehensive stock at home base.
Draw appropriate kit for a known spill.
Draw a few widely non-specific kits for
  an unknown spill: the choice depends
  on stocks and other circumstances.

Reagents

The following list covers more than 80% of the detection and identification tests given in Appendix A.

Acetic acid
[illegible]
[illegible]
Ammonia
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
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[illegible]
Maleic acid
Mercuric chloride
Methanol
Methyl [illegible]
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[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
Oxalic acid
[illegible]
Phosphoric acid
[illegible]
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NOTE: Some reagents are conveniently carried in more than one form: e.g., concentrated and dilute mineral acids, aqueous and alcoholic potassium hydroxide.

Mobile or improvised laboratory

If a mobile laboratory is to be equipped, or a room with basic utilities is available, some useful items of equipment become practical which would otherwise be marginal or impractical:

Bench centrifuge, electric powered.

Distillation appartus.

Ion exchange columns with resins.

Thin layer chromatography apparatus

Potentiometric titrator.

Light-scattering photometer for detecting precipitates.

Balance (coarse).

Gas chromatograph (at least 10-15 columns and 2 types of detectors).

Visible-UV spectrophotometer.

Atomic absorption spectrometer.

Infrared spectrometer.

CHAPTER 3

SAMPLING

3.1 Introduction

Sampling for damage assessment includes the water, organisms, and sediment in the spill zone, and control samples taken outside the spill zone.

- Test water quality *in situ* (e.g., by pH probe), or take samples and use field detection kit, to find the extent and movement of the spill.
- Look at organisms *in situ*, or take samples for local examination, to determine the nature and extent of damage. Send samples to a permanent laboratory for further examination if necessary.
- **Take samples of sediment, for comparison between sampling stations (see EPA Biological Methods Manual).**
- Take samples of water (and sediment where appropriate) with all biological samples.
- All samples for positive identification of pollutant, quantitative chemical analysis, or pathological diagnosis must be sent to a permanent laboratory.

Plan to sample organisms in these five groups:

- Were exposed to spill - found at site of spill or in path of contaminated water.
- Now exposed to spill - found in present zone of contamination.
- May become exposed - found in predicted zone of contamination.
- Harmed or dead - found anywhere that has been at risk. If biological damage is seen outside the risk area, take samples for comparison with samples from the spill zone.
- Control samples - from any location not exposed to spill, but otherwise similar to the exposed locations for which they will provide controls.

The ability of organisms to move or be carried by water currents affects their value as evidence, but is not the only consideration:

- Although freely motile organisms (fish, birds) give the least definite evidence of spill effects or as controls, because of the doubt whether they were exposed or not, they must be examined and sampled if they show damage, especially if they are economically important or legally protected.

- Immobile organisms (benthos, periphyton) give better evidence of spill effects because there is less doubt whether they were exposed or not.

- Plankton tend to remain either in or out of the zone of contaminated water.

3.2 What Biological Samples?

- Give priority to species of economic value (commercial or sport). They may be damaged in value without being killed or even reduced in vigor, if tainted or toxic to humans.

- Do not forget delayed damage: future crops may be damaged by injury to eggs, immature organisms, or breeding adults.

- Give special attention to benthic invertebrates, which link producers and secondary consumers and generally retain a "print" of damage for some time, being relatively immobile.

- Look for damage to other links in the food web: for example, plants that support aquatic and littoral life through links such as detritus-microorganism-mollusc, or plant-snail-bird. Marsh plants are particularly important in estuaries.

- Take samples of periphyton and plankton for their qualitative and quantitative value, especially periphyton in streams and plankton in estuaries.

- Look for species which might be expected to be present. Their absence may be evidence of damage. Look for records of recent and long-term presence at the site.

- If there is persistent degradation of water quality after a spill (e.g., slightly soluble material remaining on the bottom, or a spill into a lake or reservoir), consider bioassays*, in situ or in the laboratory. Choose fish, invertebrates, or embryos as test organisms, according to economic importance or technical suitability. Consider also artificial substrates for natural colonization. Always conduct control tests outside the spill zone.

3.1 What Water Samples?

Plan your water sampling, within and outside of the spill zone, to answer questions such as:

- What was spilled, and how much?
- Where is the spilled material, and in what concentration?
- Where will the spill go?
- What water uses are threatened?
- What was/is/will be the exposure of the biological communities sampled?
- What was the pre-spill water quality? This may be inferred from reference samples.
- Was there other pollution which could have caused or augmented the damage?
- Is "normal" water quality being restored, or has it been restored?

Sampling must be scheduled to look for large diurnal or other fluctuations in water quality: e.g., in dissolved oxygen, pollutant burden, turbidity, or temperature. These could strongly influence the effects of the spill and subsequent events.

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*See Biological Field and Laboratory Methods, EPA, 1973; Standard Methods for the Examination of Water and Wastewater, 13th edition, APHA, 1971.

3.4 Where to Sample: Diffusion and Transport*

A spill in water is diffused (spread) by stirring movements within the water. At the same time it may be transported bodily - e.g., by river flow. Surface material is affected by wind. Knowledge of diffusion and transport helps answer questions such as:

- What area has been exposed to the spill?
- What area will be exposed?
- Where to sample water and organisms?

Direct knowledge of the specific site is the best guide, but not often available. No two bodies of water are identical, and none is the same year round. Take the following action:

- In conjunction with the OSC, seek data which may have been collected by the Geological Survey, Corps of Engineers, State water authority, Storet, or The National Field Investigative Center, or nearby universities.
- If available data are inadequate, make estimates with the help of the guidelines in 3.5 below.
- Progressively build up a picture of local water movements as detection of the spill and observations of damage add data.
- Consider whether experiments with dye tracer or floats will be useful (e.g., to measure time of travel downstream). Remember that the value of such evidence depends on identity of conditions: flow, tide, weather.

3.5 Spread of Spill in Typical Waters

River

Characterized by unidirectional flow.
Stratification not common.

- Vertical mixing: usually rapid, soluble spill will difuse from surface to bottom in a few tenths of a mile, and much sooner in shallow, turbulent flow. However, thermal stratification may markedly suppress vertical mixing.

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* A leading reference is A Practical Guide to Water Quality Studies of Streams, F. W. Kittrell, FWPCA, 1969.

- Lateral mixing: slower than vertical mixing, and much more variable; in an "average" river, it may be complete within a few miles. However, lateral mixing takes much longer in a wide, shallow, turbulent river or a wide, smooth, straight river; it is faster in a narrow, winding or stratified river.

- Longitudinal mixing: the first detection of a spill downstream may be earlier than expected on the basis of flow data; the last trace may be much later, because of hold-up in shallows, eddies, or dense vegetation. As a general rule, use measured surface speed plus 25% to calculate time of first arrival.

Lake

Characterized by no set flow; marked effect of wind. Thermal stratification is common. It is difficult to predict the spread of a spill even if data are available from earlier observations.

- Use evidence of visible damage, fouling, or discoloration as indicator of where the spill is or has been. Also use qualitative and quantitative biological samples such as benthos or plankton.

- Use water quality or wet chemical (Appendix A) tests to detect and track the spill.

- Make full allowance for wind: floating spill moves on average at 2% to 3% of the wind speed, perhaps as much as 5%. Use wind measurements taken at the site if possible. If wind records from some distance away must be used, seek meteorological advice on their applicability to the site.

- Make allowance for thermocline (known or detected) in limiting downward diffusion or preventing upward diffusion from below. Sample at various depths, guided by the thermocline or other evidence.

Estuary

Characterized by net surface outflow, bottom inflow; retention at the salt/fresh water interface (halocline); affected by tide.

- Determine the present fresh water input: is it normal, more, or less?

- Take note of wind, present and since spill.

- Seek data which are often available for surface currents and effects of wind in major estuaries.

Look for damage, and make qualitative biological and chemical tests to determine the present and previous location of the spill.

Take account of the movement of the "salt wedge". Use available data or make observations.

Expect the spill to recycle with the tide, unless there is strong flushing by heavy fresh water runoff or high wind.

Coastal

Characterized by tidal currents, and there may be a large net flow. Marked wind effect.

Look for effects of local configuration on mixing and flow.

Look for retention of spill in pools and lagoons.

Expect recycling with tide.

Look for intermittent exposure to spill of different parts of the coastline, under the changing influences of tide and wind.

[illegible] Effect of Water on Spilled Material

In addition to transporting and diffusing the spill, the water may change it physically or chemically. Examples are:

Hydration of anhydride to acid.

Hydrolysis of metal salt to hydroxide and acid.

Emulsification, so that insoluble material behaves in many respects as though dissolved.

The spill may also be affected by substances dissolved or suspended in the water. Examples are:

Neutralization of acid by alkali.

Adsorption on suspended particles and deposition as sediment.

Reduction of oxidant by organic material.

3.7 Sampling Fish Kill*

A fish kill requires special attention because it is the form of damage that most often arouses public concern and is the damage to which a dollar value is most readily assigned; most States have established dollar values for fish killed.

Use fish kill procedure as a model for other investigations: it is the most highly developed form of damage assessment.

Counting

- Count all (or most) of the fish kill if possible: i.e., if small number, or within small area.
- If the fish kill is too large to count all fish, select representative sampling stations, report how they were selected, and substantiate the selection with evidence such as photography.
- Count fish *in situ* or collected by net, etc.
- Take account of movement of dead fish by current or tide. In tidal waters it is advantageous to have several crews counting at once.
- Look for evidence of loss to scavenging animals.
- Calculate total kill from sample counts and multiplication factor (total area/sample area).
- Don't overcount. At intervals, make a quick estimate of the total kill. Stop counting when it is evident that further counting will not significantly alter the estimate.

Taking Specimens

- Collect specimens of all species of affected fish. Collect similar numbers of control (unexposed) fish. (See instructions below on number of fish to collect)
- As a rule, take affected fish at more than one station, and especially if the area is large or there is evidence of locally different conditions.
- Preferably, take control fish at more than one station, and especially if the first control samples fail to match all samples of affected fish.

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* See *Investigating Fish Mortalities*, K.M. Mackenthun, FWPCA, 1970; Biological Field and Laboratory Methods, EPA.

- If the fish kill continues for more than one day, take further samples.

- Take further samples of affected fish if the first specimens were of doubtful value through being dead for an uncertain period.

- Check your sampling plan by reviewing use that will be made of the evidence.

- Look for factors other than the spill that might have caused or augmented the kill: e.g., "red tide", severe weather.

- Consider whether there might be different successive causes of fish kill, or different causes in different parts of the area.

- If the spill is seen to affect fish in a new area (or is expected to), give top priority to watching and recording behavior, and to taking specimens of fish and water before and during the event. Observation and sampling of an on-going fish kill gives the most favorable opportunity for successful diagnosis.

Number of Diagnostic Specimens

- Preferably, sample all species affected, at the very least, sample representative species of importance either economically (e.g., sport fish) or ecologically (e.g., herbivore, piscivore).

- Take the following samples of each species at each station:

  - For laboratory observation of gross signs, and chemical analysis of selected tissues (preserved by freezing) - 10 fish, or not less than 10 lb. (if practical).

  - For histopathology (preserved in 10% formalin) - 5 small fish.

  - For infectious disease diagnosis (preserved on ice) - 5 specimens of dying fish.

- For immediate examination on site, sample until a consistent picture has developed.

Packing and Shipping Specimens

- Alert the receiving laboratory as soon as possible.

- For laboratory examination and chemical analysis:

  Pack in individual plastic bag, seal and label. Quick freeze in freezer or with dry ice; ship with dry ice. Controls should be frozen at the same time.

- For histology:

  Pack with tenfold excess of 10% formalin or fix in excess and ship with small amount of fresh fixative. Fixative must have access to organs. For smaller fish (less than 6 in.), make abdominal incision, clip operculum, cut above and behind eyes into brain cavity; for larger fish, remove and fix organs separately, or at least remove membranes.

- For infectious disease diagnosis:

  Pack in individual plastic bag, seal and label. Ship in insulated container, preferably leakproof, with ice. Deliver to diagnostic laboratory within 24 hours, preferably much sooner.

  Plastic bags are best enclosed in a second bag. Allow for expansion if air freighted.

- Glass jars (with glass closure, home canning type) are acceptable. Surround with adequate padding, and absorbent for small leakage.

  In emergency, replicate histological samples (only) may be packed in one container. Wrap each specimen in a piece of paper towel of good wet strength.

- For taste-testing (if there is a question of damage through tainted flavor):

  Fish should be dressed and frozen quickly; ship with dry ice, and protect carefully from becoming tainted in transit.

- Freeze blood samples and ship in dry ice. Label to correspond with fish from which taken.

  Send with the samples any details which may help diagnosis, such as observed signs and suspected cause. Do this even if a report is being sent by other means.

3.8 Benthos

3.8.1 Sampling Stations

- Always sample for comparison of like with like (e.g., riffle with riffle), in any assessment that depends on comparison of test samples with one another or with reference samples.

- When sampling for exposed organisms within the spill zone, try to avoid habitats which cannot be matched by control habitats outside the zone.

- Prefer habitats that favor a large and diverse community, e.g., shallow riffle.

- Take at least three replicate samples at each station. This is very important for statistical purposes. The number should be decided on the basis of what is found when samples are examined, see Chapter 6.

- As a general principle, eliminate a station rather than take less than three samples.

- In a lake or reservoir, take samples at increasing depths on transects perpendicular to the shore.

- In an estuary, give due weight to surface and subsurface net flow, tidal excursion, and wind effects in selecting sampling stations.

3.8.2 Examination

The most important data are the kinds of organisms and their numbers, in each separate sample. These data are used to calculate:

- Composition of each community, in terms of a diversity index or other measure.

- Population density (number per unit area).

- Variability between samples at one station, which is related to adequacy of sampling.

- Variability between stations, within the spill zone and outside, which is related to damage.

initial evaluation may not require complete species identification. Consider carefully whether the labor of going beyond broad taxa (order of family) will add significantly to damage assessment.

The decision is not irrevocable, because specimens must be kept until the case is over.

- If results are not urgently required, send samples to a permanent laboratory for examination.

- If preliminary results are urgently required, examination with adequate identification can be made on site, in a mobile laboratory or improvised facilities.

- A semi-quantitative examination by sorting into groups of like organisms without identification may be made if qualified staff are more urgently engaged elsewhere. This is not an acceptable [illegible] for regular examination.

- Other data that may be [illegible] are mortality and abnormal appearance.

- As a general rule, and especially if damage is seen or suspected, retain samples for chemical or radiological analysis. Refrigerate or freeze: do not use chemical preservatives. For other than chemical or radiological examinations preserve samples in 10% formalin.

3.9 Periphyton and Plankton

The examination of periphyton and plankton follows the same general principles, aimed at species diversity, population density and sample variability; but results may only be semi-quantitative.

3.10 Measure of Damage

- Use biomass within a trophic level (or community) and species composition as a measure of damage to the food chain.

- Use the volume occupied by preserved specimens (in standard sample bottles, from comparable samples) as a simple indicator of decrease in biomass caused by a spill. It provides good material for a photograph that may be included in a report e.g., a series of upstream, spill zone, and downstream samples.

- Take care that preserved specimens do not include many organisms that were killed by the spill but not decomposed or dispersed.

3.11 Long-Term Surveillance

- Decide, early in the investigation, whether to recommend long-term surveillance. This decision may be provisional.

- Long-term surveillance is required if damage is likely to be protracted or delayed by:

  "Continuous" spill, for example by slow seepage.
  Persistent toxic spill of material with low solubility and density greater than water.
  Lag in natural recovery.
  Future catch of fish damaged by harm to immature or breeding fish, or to food web.

  Surveillance may involve:

  Physical and chemical monitoring of water quality.
  Observation of biological effects in situ.
  Observation of recovery.
  Taking biological specimens for histology, chemical analysis, etc.
  Exposure of artificial substrates for benthos and/or periphyton.
  Bioassay in situ.
  Bioassay in the laboratory.
  Records of commercial catches.

- The duration of damage is important if damage is to be assessed in terms of, e.g., man-days of beneficial use denied.

- Consider use of bioassay in situ for circumstances such as long-term exposure of oyster beds to persistent contamination, where use of sown oyster trays should give strong confirmatory evidence.

CHAPTER 4

BIOLOGICAL DAMAGE ASSESSMENT: EQUIPMENT AND TECHNIQUES

4.1 Introduction

Chapter 2 deals with methods for detecting the spill. The present chapter gives guidelines on equipment and techniques for observing the effects of the spill. This is only an outline of what is most useful for the specific task of damage assessment. It is not a comprehensive guide to field methods in aquatic biology, for which reference should be made to publications such as Methods for the Collection and Analysis of Biological Samples, EPA, 1973, Standard Methods for the Examination of Water and Wastewater (13th Edition), APHA, 1971, The Practice of Water Pollution Biology, K. M. Mackenthun, FWPCA, 1969, Investigating Fish Mortalities, K. M. Mackenthun, FWPCA, 1970, and EPA Training Manuals.

Sampling must be supervised by a qualified individual, who is responsible for selecting the best equipment and techniques for each incident and for data evaluation. Qualification is determined primarily by credibility as a witness in court: training, experience, and ability to present evidence convincingly.

4.2 Selection of Methods

Ask yourself whether your proposed methods are:

- Technically defensible, and/or generally accepted, and quoted in standard texts such as those referenced above?
- Suitable for collecting statistically sound samples?
- Suitable for gathering comparable test and control samples?
- Able to collect adequate samples within the manpower and time available?
- Able to give quick preliminary results?
- Fully adequate for economically important species?
- The best overall for evidence about this spill?
- The ones you are accustomed to, and prefer to use?

High standards of performance, care, and documentation are as important as standardized methods. However, consistently uniform procedure is most important when the damage report hinges on comparison of test and control or reference samples. This is especially true in the statistical evaluation of the data.

Select methods to look for effects that show damage to man's beneficial uses of the spill area, or that help the investigation of damage. Prepare to report fully on:

- Nature of damage: what organisms and water uses were harmed? in what way?
- Extent of damage: how many fish killed? how much shoreline fouled, how severe was the damage? how long did it last?
- Cause of damage: what was the substance that did the damage? (The question of where it came from is not a part of damage assessment).

4.3 Biological: General

Decide which of the following groups of organisms are to be sampled:

- Organisms always within the water (benthos, periphyton, plankton, nekton). These usually provide the most useful evidence. Sampling is mainly by dredge, trawl, net, etc. SCUBA visual survey and sampling may be a great help.
- Intertidal organisms. These are exposed to the spill only if the tide is in while spilled material is present. Thorough sampling of quadrant or transects is practical, under visual control.
- Inshore, immobile organisms. Exposure is limited to abnormal conditions of heavy vapor concentration or airborne spray. Sample only if there is observed damage or report of high wind and storm tide.
- Water surface and inshore, mobile organisms (insects, birds, littoral mammals). These are the least likely to give useful evidence. Prepare to sample only "damaged" specimens, and remember that it may be uncertain where and when they were exposed. Unharmed specimens are of little value (especially as controls): were they ever at risk?

4.4 [illegible]

- The choice of samplers is determined by the character of the substrate and other circumstances. Use a grab (gravity-closed or spring-closed) for samples including substrate and organisms within it. The former is preferred (less liable to displace epibenthic organisms). [illegible] (for its strong "bite"), Ponar, etc.

Take a sample of substrate from each station, for:

Comparison between stations.
Chemical analysis, to correlate with heavy metal, pesticides, etc., found in organisms.

If conditions permit, wash samples on site through a U.S. standard #30 sieve. Washing is better done before [illegible] organisms, and you will have less material to transport.

Small samples washed on site for quick [illegible] provide [illegible] evidence of the adequacy of sampling. Are the numbers of organisms enough for statistical purposes? Are samples from any one station abnormally variable?

Use the washed samples also as a preliminary guide to nature of fauna.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

4.5 Periphyton

The periphyton may supplement evidence from the benthos as to linear extent and severity of damage. Quantitative results are difficult to obtain except with artificial substrates, which are useful for damage assessment only if long-term surveillance is planned.

- Sample periphyton (whenever practical) by removing portions of substrate, scraping, and washing off into a container.
- To sample in situ, scrape substrate and hold a fine-mesh net close downstream.
- Uniformity of procedure is essential if samples are to be compared.
- If samples of periphyton or benthos are taken for chemical analysis, preserve by refrigeration or freezing, not with chemicals.

4.6 Plankton

- In general, use a water bottle sampler for phytoplankton and a net for zooplankton.
- Use a non-metallic water sampler (e.g., plastic Van Dorn), especially if samples are to be analyzed for trace metals or used for primary productivity or other metabolic rate measurements.
- Prefer a metered net if quantitative zooplankton samples are desired - but uniform tows with an unmetered net are acceptable.
- Select net mesh with the intended samples in mind. Do not use unnecessarily fine mesh, which may clog.
- A water pump, dip tube, and filter may be used for plankton, but is not recommended for delicate algae or larger zooplankton.

4.7 Fish

- Collect floating dead fish by hand net, from shore or boat.
- Collect dead fish from the bottom by hand net, if in shallow water, or SCUBA if deeper, alternatively, search with any available bottom trawl.

- Always attempt bottom inspection or sampling if there is any indication or suspicion of fish kill.

- Select collection methods for live control fish according to the species and sizes found dead. E.g., use bottom trawl or mid-water trawl for active collection in a species' known habitat; use gill net for highly selective collection of a particular species and size. Refer to the EPA Biological Field and Laboratory Methods.

- Use the haul seine for general collection in shallow water, unless bottom snags interfere.

- Consider advantages of electrofishing (in fresh water).

4.8 Macrophyton

Vascular plants may show visible damage (often after delay) or may act as collectors for contaminant.

- Recommended equipment includes map or chart; Polaroid camera, grappling tool (rake) and knife, SCUBA; frames, and cord and stakes, sample containers.

- Before sampling, survey the area on foot, by boat, or by air.

- Select plants for sampling by:

  Visible or expected damage.
  Adherent contamination.
  Ecological importance (as food directly, as detritus, or as habitat).

- Give careful consideration to the value of aerial photography (visible or I.R.), probably at several time intervals, in a large-area incident, or if quantitative sampling of macrophyton is hard to achieve because of difficult access or irregular distribution of species and density.

4.9 Intertidal and Inshore Zones

- Sample small and numerous organisms within a frame of 1 m^2 or less.

Separate from substrate according to its nature: e.g., wash clay samples through a screen; hand pick and brush or scrape pieces of rubble, and wash into a container.

Count and sample large and scattered organisms (e.g., dead birds) within transects of suitable extent.

Randomize quadrant and transects with due regard to circumstances: e.g., if organisms are grouped in narrow zones parallel to the shoreline, they are best sampled by transects perpendicular to the shoreline.

Select methods with extra care if there is damage to animals or plants that attract unusual public attention.

For macrophyton, see 4.2.

3.[illegible] Other Damage

Damage to man's beneficial uses of a body of water and its immediate vicinity may also affect:

Recreational use, habitability for man, and aesthetic values.

Property: structures, vessels, beaches.

Withdrawal uses: industrial, municipal, agricultural.

Your investigation of these will be mainly by visual observation, [illegible] inspection of records, and sampling for extent and nature of contamination.

Basic equipment is:

Notebook, suitable for permanent record.

Tape recorder (especially suitable when time presses).

Camera, [illegible] for photographs and [illegible]

[illegible] of the scale.

Chemical detection kits, sample jars.

[illegible]

4.11 Checklist of Equipment

This is a checklist of equipment that is commonly needed for field assessment of biological damage. Use it when preparing for an investigation. The specifically named items are typical ones, not intended to exclude others that may be available or preferred. Accessory items (such as string, tape, tools, tow lines) are not covered. The list is arranged by function as a reminder of what should be available for each field task that is anticipated.

General	Notebook Tape Recorder Labels, waterproof Soft pencils (or other waterproof, non-smudging markers) DO meter and kit pH meter or paper Chemical test kits Sample bottles, various Specimen containers (including plastic bags) Sealing tape Preservatives (Formalin, alcohol, acid) Ice chest Linear measure (tape, ruler) Maps, charts Camera (Polaroid) Scalpels, scissors SCUBA Waders and rubber gloves
Plankton	Water bottle for phytoplankton: Van Dorn, Net and tow for zooplankton: Clarke-Bumpus Pump, filter, and tubing
Productivity of Phytoplankton	Light and dark bottles Line or rack for bottles Water sampler (non-metallic, opaque) Pyrheliometer Labeled carbonate for radiocarbon method
Periphyton	Scraper Artificial substrates

Macrophyton	Grab: Ekman, etc. Frame, or poles and lines Rake SCUBA Aerial photo, including I.R.
Benthos	Grab: Ponar, Ekman, Smith-Macintyre, Shipek Surber Core sampler: Phleger (Dendy) Nets: tow, trawl, dip Hand screen Artificial substrates Tweezers and knife
Sediment	Grab Core sampler
Fish (live)	Seine Gill net, trammel net Trap: slat, hoop, fyke Trawl Electrofishing equipment
Fish (dead)	Dry ice (as well as chemical preservatives and ice) Hand net

CHAPTER 5

DAMAGE ASSESSMENT PROCEDURES

5.1 Introduction

This chapter gives guidelines for applying the field investigation to damage assessment, in quantitative terms whenever possible. Damage assessment is the measurement of harm done to man's beneficial uses of a body of water and its immediate environment. Examples of beneficial use are commercial and sport fishing, recreational boating and swimming, and withdrawal of water for municipal, industrial, or agricultural use.

5.2 Objectives

Your objectives are to:

- Identify all beneficial uses damaged.
- Assess the damage to each, in quantitative terms whenever possible.
- Identify the damages that are attributable to the spill.
- Eliminate other possible causes, or assess their contribution.
- Prepare a fully documented report.

5.3 Procedure

Using the information gained during your survey:

- Review all water uses (see 5.4) which apply to the spill area, and determine which were at risk or still are.
- Determine the types of damage (5.5) to which each water use is liable.
- Select the most quantitative measurement (5.6) applicable to each type of damage.
- Continue the field investigation accordingly, concentrating on the observations which you have now identified as being important.
- Review causes of damage (5.7).
- Report your assessment of damage (5.8) and its causes. Distinguish clearly between damage (a) directly observ (b) inferred, but not directly observed, and (c) pred

[illegible] Water Uses

	Examples
Non-withdrawal uses	Fish - commercial, sport Aquaculture - animals, plants Recreational - boating, swimming
Withdrawal uses	Municipal - domestic, commercial Industrial - through municipal, or self-supplied Agricultural - irrigation, watering stock
Miscellaneous uses or aquatic environment	Property in contact with water - structures, beaches Habitat - man, other organisms Aesthetics

Review all uses at risk because of the spill. Do not let conspicuous damage obscure less obvious but significant uses.

Establish a sound reason for each use that is not to be investigated. If the reason is not self-evident, document it.

[illegible] Types of Damage

	Examples
[illegible]	Killed Quality degraded - tainting, toxic Supporting food chain damaged Breeding generation damaged } leading to delayed effect Immature organisms damaged }
Recreation	Man-days of use lost
Withdrawal uses	Municipal and Industrial - supply interrupted, extra water treatment needed, premises or equipment damaged Agricultural - crops or stock damaged
Property	Beach fouled Structures damaged

	Examples
HABITAT	Economic species damaged or driven away Appearance degraded

- Decide which types of damage require a reported assessment. If in doubt, include rather than exclude.

5.6 Measurement of Damage

The emphasis is on quantitative measurement.

	Examples
ECONOMIC SPECIES	Number killed of each kind Number of degraded quality, and severity of degradation Area of damage Duration of delayed damage through loss of immature or breeding organisms Duration of persistent pollution Number or mass of lost harvest (measured or predicted)
RECREATION	Man-days of use restricted or totally denied
WITHDRAWAL USES	Duration of restricted use or denial Number of items damaged Cost of special water treatment Number or mass of lost harvest
PROPERTY	Area damaged, or number of items Man-days of use restricted or denied Severity of damage Duration of damage Cost of restoration
HABITAT	Damage to economic species, etc., through degradation of habitat rather than direct effect, units of measurement as above

5.7 Causes of Damage

Establish clearly how each type of observed damage is related to the spilled material.

Be specific and quantitative: not "Chemical analyses showed X concentration" but "Samples 1 through 20 contained X in excess of 5 mg/l (range 15 to 50 mg/l)."

Review possible causes of damage other than the identified spill.

Examples are:

Man-made causes: interference with volume of flow, interference with stratification, clearing of aquatic weeds, agricultural run-off, sediment run-off, industrial pollution, unrelated spill.

Natural causes: extreme temperature or drastic change, storm, ice and snow, decomposition of plant growth, salinity change, spawning mortality, infectious disease, parasitism.

Be specific in rejecting other causes: e.g., if natural oxygen deficiency is ruled out, use DO analyses from control sampling stations.

Do not investigate how the spill was caused, unless this is relevant to damage assessment.

5.8 Essential Contents of Damage Assessment Report (Summarized)

Your damage assessment report may be used as the leading source of information for preparing a court action. It must meet these requirements:

It must contain all the facts on which the damage assessment is based, or tell the reader where to find them.

It must be suitable for use years after the spill by someone coming to it "cold", who will need all possible assistance in tracing documents and witnesses.

It must be a clear history of what happened, what was done, decisions and conclusions reached, and the reasons for all actions.

It must cover the following areas:

Incident - what happened, requiring investigation.
Investigation - what the damage assessment team did.
Other information - who else investigated, where is other information.
Damage - what kind, how much, what cause.

Damage assessment reports are discussed more fully in Chapter 7. Study these closely. Your report is the product that comes from all the effort expended in the field.

CHAPTER 6

STATISTICS

6.1 Introduction

This chapter gives guidelines on the application of statistics during the field investigation. It assumes a knowledge of elementary statistics as presented, for example, in EPA Training Manual Chemical Analyses for Water Quality, Section II.

A reminder of some basic points is desirable. Most statistical methods that will be used are based on the assumption of normal (Gaussian) distribution of variables, with the familiar bell-shaped curve of which 68% is within one standard deviation of the mean, 95% within two standard deviations, and 99.5% within three. However, the normal distribution is almost never a precise description of random natural phenomena, and cannot be assumed without direct empirical proof of its applicability. Remember also the distinction between precision and accuracy: Precision is the closeness with which replicate measurements agree, and accuracy is the closeness of the mean measured value to the true value.

Calibration of instruments, reagents and techniques should be made before and after each investigation as far as practical. This is important whenever data are to be statistically analyzed, as well as for support of a legally sound damage report.

Equipment to take into the field includes Student's t tables and chi-square tables, and a pocket calculator, log tables and slide rule according to personal preference.

6.2 Selection and Evaluation of Field Techniques

Choosing and applying any quantitative sampling or assessment technique requires knowledge of its inherent precision in normal use. For example, replicate dredge samples of benthic invertebrates give different counts even from a uniformly distributed population, and replicate titrations of a single water sample give different values. Be prepared with numerical estimates of accuracy, based on your own experience and that of others, against which observations may be tested. Make rule-of-thumb criteria for checking field observations. For example, experience might be that three replicate samples by a particular technique often give values with a twofold range.

To determine the accuracy and precision of a measurement or evaluation technique for which a known standard exists* (such as a volumetric titration):

- Prepare a standard solution of the substance to be analyzed.
- Make several replicate determinations (N).
- Calculate the mean and standard deviation (S).

* Note: Standard reference samples of many pollutants are available through the Methods and Performance Evaluation Activity, Analytical Quality Control Laboratory, EPA, Cincinnati.

The estimated accuracy of the technique is the difference between the mean measured and the true value.

For N determination with standard deviation s, the true accuracy of the determination is equal to or less than:

the estimated accuracy plus $\frac{ts}{\sqrt{N}}$

For a confidence level of 90%, use a t distribution table (e.g. Fig. 4-1) for N-1 degrees of freedom to find t at the 10% (or 0.1) probability level.

For N determination with a standard deviation s, the true precision of the determination is equal to/or less than:

the estimated standard deviation (s) times $\sqrt{\frac{N}{\chi^2}}$

For a confidence level of 90%, use a chi-square table for N-1 degrees of freedom to find the chi-square value at the 10% (or 0.1) probability level. Determine the chi-value before use in the formula above.

As a general rule, and especially if there is any possibility of interference, also check precision and accuracy with a standard prepared with water from the body of water under investigation.

By use of the above guidelines, you can determine if your technique or method is accurate or precise enough to warrant further field work. For example, are the accuracy and precision of your technique sufficient to:

Look for damages directly attributable to the concentration of material you are measuring?

Track the movement of the material at these concentrations?

4-3 Sampling Plan

Chapter 3 gives guidelines for sampling, such as taking at least three replicate samples each time at each station. Using this guidance and your own experience, a rough sampling plan may be made, but it is necessarily tentative until some data are available. Make every effort to get quick results; preferably full analyses and counts, but preliminary estimates will serve as an immediate check on the adequacy of the data. This is particularly important whenever the results are to be statistically analyzed later.

2.4 [illegible]

The number of samples required at any station to give a sound average or mean will depend on the closeness of agreement between samples. In other words, the dispersion of data [illegible] the standard deviation. The confidence interval [illegible] the confidence one may have in the sampling. For example, assume a [illegible] which yields the following [illegible] values [illegible]. The sample mean is, therefore, equal to [illegible].

Calculate the sample standard deviation (S) as:

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

where n = number of samples or tests, x_i = the [illegible] of each sample, and $\bar{x}$ = the sample mean.

In this case, S^2 = [illegible] and S = [illegible].

Calculate the sample standard error, $S_{\bar{x}}$, as $S_{\bar{x}} = S/\sqrt{n}$ = [illegible]

From a t distribution table, [illegible] value of t_{n-1} with the degrees of freedom [illegible]

Calculate $(t_{n-1})(S_{\bar{x}})$ = [illegible]

The confidence interval is, therefore, [illegible] ± [illegible]

It can be said with confidence that the calculated interval includes the true mean value [illegible] have occurred in the sampling.

Next, consider the following set of data for a similar station.

[illegible] represent the [illegible] values for each of [illegible] samples.

Calculate the sample average, $\bar{x}$ = [illegible]

Calculate the sample standard deviation (S) as above. S^2 = [illegible]

Calculate the sample standard error, $S_{\bar{x}}$, as above. $S_{\bar{x}}$ = [illegible]

t_{n-1} for n = [illegible]

Calculate $(t_{n-1})(S_{\bar{x}})$ = [illegible]

In this case, the confidence interval is [illegible] ± [illegible]

A large confidence interval may indicate that additional samples are required. As a general rule-of-thumb, the following may be used to judge the results of a "valid" sample:

Take 5 samples at each station.

Analyze 3 samples and calculate the confidence interval.

If the interval is unacceptable, analyze the other 2.

Is the new confidence interval acceptable?

Are additional samples required?

When collecting data such as counts of a fish kill, test the adequacy of sampling by making a quick calculation of the cumulative estimate after each sample area is counted. Inspect the successive estimates, or plot estimated total vs number counted. It will be apparent when the estimate is at the desired level of precision (e.g., ± 10%) and further counts are unlikely to shift the total outside this range.

6.3 Is An Observed Difference Significant?

Assuming a minimum of 3 replications, test for significant difference between control and sample values by the following method:

Compute $t = \frac{(\bar{x} - d)\sqrt{N-1}}{s}$

where $\bar{x}$ = sample average, d = the control or set value, N = number of samples, and

$s^2 = \frac{1}{N-1} \sum (x_i - \bar{x})^2$ where x_i represents the individual sample readings.

Find your computed t value for N-1 degrees of freedom on Fig. 6-1.

Is there a significant difference between the control and sample value?

The 10% probability level indicates that the t value will be exceeded by chance only once every 10 trials, the 5% level 1 in 20, etc.

If the calculated t value exceeds the 10% level, the control and sample are possibly significantly different. A t value exceeding the 5% level indicates probably significant differences; t exceeding the 1% level indicates significant difference; t exceeding the 0.1% level indicates highly significant difference between the values.

This method assumes that the control value is known and not subject to statistical variation. Suppose that past records on a given stream show a pH value of 7.40 from literally hundreds of readings. Following an acid spill, 3 pH readings were taken near the monitoring station and their values were: 5.15, 5.20, and 5.40.

Compute: $t = \frac{(\bar{x}-d)\sqrt{N-1}}{s}$

where $\bar{x}$ = sample mean (7.25), d = the control or set value (7.40), N = the number of samples (3), and

$$s^2 = \frac{1}{N-1}\sum(x_i-\bar{x})^2 = \frac{1}{2}(0.10^2 + .05^2 + .15^2) = 0.0175$$

where x_i represents the individual pH readings.

The calculated value of $s = \sqrt{0.0175} = 0.132$

$$t = \frac{0.15\sqrt{2}}{0.132} = 21$$

In the example, the t value of 21 at N-1 degrees of freedom (2) falls well above the 1% probability level and the observed differences are significant.

A variation of the above method that may be used to test for significant differences, when the same number of samples are taken at both stations, considers the standard deviation of each set of data. Use the Diversity Index data given in the examples on page A-2, and test for significant differences between the two sample means.

For one set of data, $S_1^2 = 0.0434$. The other set of data, $S_2^2 = 0.610$.

Calculate the average sample standard deviation, S_{12}^2, by

$$\frac{S_1^2 + S_2^2}{2} = 0.327$$

Calculate the average sample standard error squared,

$S_{\bar{x}}^2$, by $\frac{S_{12}^2}{N} = \frac{0.327}{3} = 0.109$

(N = the number of samples taken at each station)

Calculate the sample standard error for the difference, $S_{\bar{x}_1-\bar{x}_2}$, by

$$S^2_{\bar{x}_1-\bar{x}_2} = 2S^2_{\bar{x}} = 2(0.109) = 0.218$$

then, $s_{\bar{x}_1-\bar{x}_2} = \sqrt{0.218} = 0.467$

Compute t by: $t = \frac{\bar{x}_1-\bar{x}_2}{s_{\bar{x}_1-\bar{x}_2}} = \frac{4.9-3.7}{0.467} = 2.44$

Find your confidence level from Fig. 6-1 using 2(N-1) = 8 degrees of freedom and the computed t value.

The t value falls below the 10% level indicating that the difference between the two sample means is probably not significant.

6.6 Legal Requirements

Refer to Chapter 7, which gives general guidelines. Typical questions which may come up in the statistical area are:

- Were concentrations actually above a certain level, such as a published TL_m or local water quality standard? The variability here is in sampling and analysis. Data must be adequate to show statistically significant excess above the given limit.

- Were concentrations in animal and plant tissue due to the spill and above toxic threshold? The additional factor here is the wide natural variation in uptake between apparently similar individuals: Ranges of 3:1 or 5:1 are not uncommon in half a dozen specimens. The importance of adequate control specimens is very clear.

- Were sample areas representative? Randomize areas to avoid unconscious bias. Wherever possible, do not let convenience of access influence selection of stations.

- Was an adequate total number counted? More rigorous treatment of the cumulative-estimate criterion, recommended above, will give a numerical value for the confidence limits.

6.7 Preparing Statistical Evidence

Final statistical analysis and presentation of statistical evidence is best done by a statistician. There are two pitfalls which may be the basis on which evidence is questioned, and which the field investigator should bear in mind:

- The standard statistical tests of hypothesis (student's t, chi-square, F, the analysis of variance) are all based on the assumption that the underlying measurements follow the normal distribution. As already indicated, the applicability of these to natural phenomena may have to be demonstrated by statistical argument.

The populations under investigation must have the same variances.

The variables involved must have been measured on, at least, an interval scale, so that it is possible to use arithmetic operations on the values obtained.

For the F-test, the means from the normal (and homogeneous) populations must be linear combinations of the effects being studied; so that the effects under evaluation are additive.

Biological and microbiological data normally do not have data measured on interval scales. Water quality data usually does not have the equal variances nor the homogeneous populations required above.

In previous tests, the population was assumed normal. Population parameters were compared to determine whether two or more populations are identical. In non-parametric tests, the entire distributions are compared, rather than any characteristic parameters. Because these tests require no knowledge about the distribution of the underlying population, they are also referred to as distribution-free tests.

Probability charts, or graphs, are a highly efficient method of testing distribution assumptions. This results primarily because one is plotting the cumulative distribution function which appears as a straight line on the probability graph. Failure to obtain a straight line can result from:

An incorrect choice of the expected distribution form.

Non-linearities caused by non-random sampling.

Non-linearities caused by truncation resulting from inspection, selection, or other kinds of screening of data.

"Wild" points, usually indicating errors in obtaining or recording of data.

Each of the above categories results in rather consistent patterns on probability plots. Visual examination of a probability plot, therefore, is an easy test for consistency of sample data and of the underlying statistical assumptions about sampling and the validity of observed data.

6.9 Round Off Procedures

Since all measuring equipment has limited accuracy, the measurements are also of limited accuracy and thus consist of numbers which have been rounded off, e.g., if an instrument is accurate to tenths of minutes and a time measurement is 12.2 minutes, the time may actually have been any value between 12.15 and 12.25 minutes.

When test data are used to compute test item characteristics, such as the mean and standard deviation, the results must be consistent with the original data, i.e., the mean diversity index values cannot be more accurate than the individual values used to compute the mean. The following are some basic rules concerning significant figures and the rounding of data.

Significant figures (significant digits) are the digits of a number that begins with the first digit on the left that is not a zero and that end with the last digit on the right that is not a zero or that is a zero which is considered accurate. For example:

[illegible] has five significant digits
[illegible] has five significant digits
[illegible] has one significant digit
5300 has two, three, or four significant digits depending on whether the instrument used to obtain this measurement is accurate to hundreds, tens, or units, respectively.
100.0 has four significant figures.

When a number ends with a zero which is to the right of the decimal point, the zero is significant.

The result of a series of arithmetic operations must be rounded off to an accuracy consistent with the least accurate measurement in the original data. The generally recommended procedure is to carry at least two extra significant digits throughout the computations before rounding off the final result. If a calculator is used for the computations, the significant figures will depend on the capacity of the calculator.

Some numbers are considered totally accurate due to the fact that they are not the result of a measurement, and thus they do not limit the number of significant digits in the final result, e.g., degrees of freedom or required or desired significance levels. Values taken from tables are accurate only to the number of digits given in the table.

In rejecting superfluous and inaccurate figures, increase by 1 the last figure retained if the following rejected figure is 5 or more.

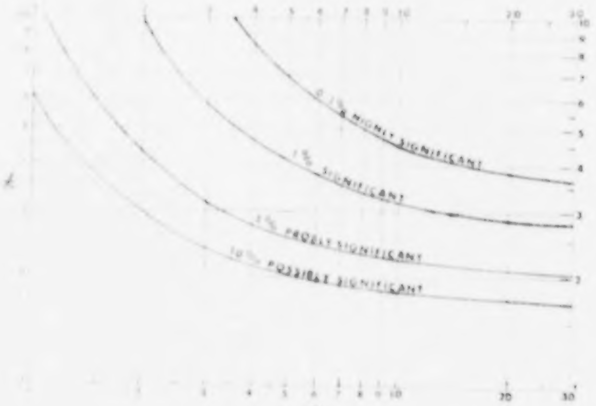

Figure 6.1 Graphic Display of Student's t Table

CHAPTER 7

REPORTING AND LEGAL REQUIREMENTS

7.1 Introduction

This Chapter is for use during a field assignment, to remind you of the special requirements for a damage assessment report that may be used in legal proceedings. It is only for this; it is not a textbook of scientific and legal requirements, nor is it a guide to the preparation of a court case.

Your investigation and report may be discredited even though you do a competent job by ordinary standards. Questions like these may be asked: Is it possible that sample labels were accidentally interchanged? Could someone have accidentally contaminated a sample with the chemical that was found later by analysis? What proof is there that this photograph was taken where and when you say? Why is this observation in the typed report but not in the original field notes? What effort was made to check this eye-witness's story? The preservative added to the samples: was it checked for absence of the pollutant found by analysis? Why did you not use one of the procedures in an EPA manual or the latest edition of Standard Methods?

Failure to have an adequate answer for just one such question may seriously weaken the value of your report, or destroy it entirely.

7.2 Scientific Requirements

The emphasis is on conformity with standard practice, consistency of method and solidity of supporting facts for every statement and conclusion.

Ask these key questions:

- Are your methods and equipment approved in every detail by EPA or another recognized authority? If not, are they technically defensible?
- Would they be acceptable to the majority of independent experts?
- If there is another school of thought, would its experts nevertheless agree that your methods have wide acceptance?
- Is there solid support for every reported observation and conclusion? (e.g., written evidence, preserved samples, authenticated photographs)

Does the statistical validity of observations meet generally acceptable standards?

Are there expressions of opinion which could have been supported by evidence but are not? (Omit them, or state clearly that they are unsupported opinions.)

1.3 Legal Requirements

The emphasis is on ability to support every statement in the most direct and unequivocal way that is reasonably practical, by such means as first-hand witness, original records made at the time of observation, and labeling of samples that cannot be accidentally interchanged.

Ask these key questions:

Are samples flawlessly identified as to origin?

Have samples been flawlessly protected from substitution, alteration, or tampering throughout your custody of them? Were they adequately sealed?

Are notebooks of original and immediate records available (as far as practical)?

Have records been protected from confusion and loss?

Have other items of evidence been similarly identified and protected?

Is there documentary evidence of every transfer of samples, etc., from you to another custodian?

1.4 Rules

Rules for meeting the scientific and legal requirements are given together here, because they overlap.

Identification

Attach identification to objects at the earliest opportunity. For example, label samples immediately as they are taken; title, sign and date Polaroid photographs at once; include data/place card in other photographs if possible.

Always include names and addresses of witnesses who can testify to origin and authenticity.

- Ensure that identification cannot become blurred, lost, or interchanged.

- Plan methods and details of identification as part of the plan of investigation.

- Make certain that every piece of evidence can be identified with the incident from which it came.

- Make certain that there is no possibility of confusion: e.g., if there is more than one "Sample No. 1", each must carry a different date, station number, etc., on the same label as the sample number.

Custody

- Ensure that samples are always under observation or locked up.

- Keep written records of who has custody at all times, and of all transfers of custody.

- Minimize the number of custodians: every one may be called on as a witness.

- Attach a transfer tag to samples when practical, and fill in the tag with the required information, including: (1) Originator's name, date of origin, name of next custodian, date of transfer; (2) Name of custodian, date of receipt, how received (by hand, mail, etc.), name of next custodian, date of transfer. There should be several similar spaces for further custodians.

- Control keys carefully. Unless there is good reason otherwise, have one set only, held by the assessment team leader.

Samples

- Label immediately, in accordance with the instructions under Identification. For example, use a waterproof adhesive label. Do not use grease pencil on outside; do not label interchangeable screw caps.

- Seal to protect from inadvertent contamination: e.g., with tape over cap.

- Label should carry (a) identification number, tying that sample in with the relevant notebook entry, (b) incident identification (e.g., name of water body), (c) printed name of sampler, and (d) signature and date. These must be on every sample.

Indicate preservative added or storage conditions required: e.g., "in 10% formalin", "keep refrigerated." This information may be on the outer container for a number of samples if they will normally be stored in this container.

Retain samples after analysis (or duplicate samples) whenever they would be usable later as supporting evidence: e.g., preserved organisms, water samples with stable chemical pollutant.

Notebooks

Use a bound notebook (not spiral bound) with sequentially numbered pages. Do not use loose-leaf, etc.

Never take notes on scratch pad or odd scraps of paper.

Make notes at the time, or earliest opportunity thereafter.

Keep original notes, even if clean-up transcripts or typed copies have been made.

Make notes chronologically as far as possible. Close out each day with a line, date, and initial. Cross any page with two diagonal lines.

Do not disrupt the sequential numbering by removing pages from the notebook.

Field observations and sampling records must be signed on the spot, and countersigned if there is a second witness.

Laboratory records must be signed by the man who did the work (or by the leader of a team).

Laboratory records should be checked (preferably by the assessment team leader) for arithmetical accuracy, correct transfer of data to graphs, completeness, legibility, and neatness.

The record must clearly identify all evidence which is physically separate: samples, annotated maps, photographs, etc. Each of these pieces of evidence must carry its own identification and authentication.

Essential Contents of Damage Assessment Report (Details)

[illegible] report [illegible]

1. History of the investigation, and guide to what evidence exists and where:

   What was done, and why.

   What were the results.

   Who were the investigators.

   What evidence exists.

   How to track down all witnesses,
   records, and physical evidence.

2. Basis for assessing costs of damage.

3. Basis for preparing court action.

4. Guidance for improved damage assessment procedures.

A damage report IS NOT:

1. Intended for countermeasures, restoration, or enforcement.

2. A compilation of all available information about an incident; it may summarize, and refer to other more detailed sources.

3. An assessment of damage in dollar values.

An outline of what should be in a damage assessment report is given below. There are four main headings:

INCIDENT - What happened

INVESTIGATION - What the team did

DAMAGE - What damage was found

CAUSE - What was the immediate cause

Use this outline as a checklist for planning and conducting a field investigation, and as a test for the completeness of your report. It may also be used as a guide for drawing up procedures, instructions, and reporting forms.

INCIDENT

Spill reported: Date
                   Time
                   Place
                   Material
                   Quantity

Damage reported
Date .....
Time .....
Place .....
Nature ..... (in brief)

INVESTIGATION

Assessor was informed
Date .....
Time .....
By ..... of ..... (affiliation)
How .....

Investigation began
Date .....
Time .....

ended
Date .....
Time .....

Report written
Date .....

Assessment team leader
Name ..... of .....
Address .....
Phone .....
Field location ..... (if still there)

Assessment team
Names ..... of .....
Addresses, etc. if different from team leader

[illegible]
Name ..... of .....
Address .....
Phone .....
Field location .....

Other officials at site
Names ..... of .....
Addresses .....
Phones .....
Field locations .....

Witnesses
Name .....
Address
Phone ..... for each one
Witness .....

First observations: results of the survey (Chapter 1), and basis for plan of investigation.

Date ......
Time ......
Water appearance: body ......
surface ......
bottom ......
Spot tests of water quality ......
Water state ...... (flow, tide)
Damage: living things ......
extent ......
Damage: other ...... extent ......
Weather ...... (during survey)
Overall plan ...... (briefly)

Weather report: from before spill to end of investigation; summarize essential features and note where detailed records are.

	At time of survey	Between spill and survey, summary
Air temperature	......	Max......Min......
Water temperature	......	Max......Min......
Precipitation	......	......(Total)
Wind speed	......	......
Wind direction	......	......
Sun	......	......

Source and location of weather records

(EXAMPLE)

Parameter	Observer	Location of original
Wind	NOAA/NWS	Weather Station at XYZ

Stations: a table of numerical identification, location description, and types of sample taken.

(EXAMPLE)

Station number: corresponds with map or sketch no.	Location	Description	Types of sample taken
11	50 ft upstream of LONG BRIDGE 6 ft from SE bank	Shallow riffle	Benthos (Surber) Water
27A	Transect No. 2 (Chart XY) High tide mark	Sand	Oiled birds Oil

Relevant maps are: (a) attached ......
(b) available at ......

History of investigation: a narrative must be compiled while the work is going on; a suitable format is a brief diary, attached as Annex A to that report. It is essential to make each day's entries against a standard set of headings: e.g., samples; observations; laboratory work; activities; reasons (where not obvious)

EXAMPLE:

Date	Action	
May 8	Samples	Benthos No. 37-78. Water No. 10-15
	Observations	Photos No. 15-25
	Lab. work	Qualitative analysis of benthos samples No. 1-36. Shipped water samples No. 1-15 to XYZ Lab.
	Activities	Weather records studied at XYZ Airport
	Reasons	--------
May 9	Samples	None
	Observations	Photos No. 26-35. Aerial I.R. photos No. 1-10
	Lab work	Qualitative analysis of benthos samples No. 37-78. Shipped benthos samples No. 1-36 to ABC Lab.
	Activities	Conference with OSC on scope and duration of damage investn; see memo, Anon to Et Al, dated May 9
	Reasons	Sampling suspended to avoid interference with cleanup; restart May 10. Aerial I.R. for damage to marsh grass; repeat on or about June 9.

The following categories are those most likely to appear in damage reports:

- Aquatic organisms - benthos, periphyton, plankton, macrophyton, fish and other nekton
- Intertidal organisms
- Inshore organisms
- Human recreation and living uses - water contact, vessels, structures, beaches
- Withdrawal uses - municipal, industrial, agriculture

Some examples follow.

(EXAMPLE)

Damage to fish:

Extent (area) of kill .....
How measured .....
Severity ..... (light, med., heavy, total)
Duration of kill .....
Dead fish: species ..... size ..... number .....
appearance (ext.: fins, gills;
internal) .....
Living affected fish: behavior ..... species .....
size ..... number .....
Total dead by category: game ..... commercial .....
other .....

Table of Specimens

Spec. No.	Station No.	Description	Sent
1	1	Kind	To .....
		Number	By .....
		Preserved	On .....

(EXAMPLE)

Damage to benthos. (Report for each sampling station)

Station No. .....
How sampled .....
Number of samples .....
Size of samples .....
Total organisms .....
Total taxa .....
Each taxon: name ..... number .....
Unusual distribution, population, mortality, etc. .....

(EXAMPLE)

Damage to human recreation and living uses. (Less standardized format than previous examples; be as quantitative as possible; use photographs, sketches, signed statements, etc. wherever practical. Things to report include:

What structures, etc. .....
Location ..... Severity .....
Extent ..... Duration .....
Type of damage .....
Active restoration .....
Natural restoration .....
Occupancy affected .....
Offense to senses (sight, smell) .....
Recreation affected: swimming ..... boating .....
fishing .....

(EXAMPLE)

Damage to withdrawal uses.

Uses affected: identify within each group:
municipal ..... industrial .....
agricultural ..... other .....
How affected: damage ..... denial of use .....
duration of denial ..... treatment
needed ..... cost .....

CAUSE OF DAMAGE

Report on the immediate cause of each major category of damage. Present the specific evidence, and show where it is to be found.

Damage to ..... was caused by substance .....

(EXAMPLE)

Evidence	Location of evidence
Water sample No. 123: x mg/l of Z	File No. 01, XYZ lab.
Pathol. report No. 456	File No. 02, ABC lab.

Positive identification of substance supported
by ....
OR Presumptive identification of substance supported
by ....
OR No identification of substance: explain .....

Alternative causes of damage specifically excluded:

1. ....: evidence ....
2. ....: evidence ....

APPENDIX [illegible]

DICTIONARY OF HAZARDOUS
POLLUTING SUBSTANCES

Each substance is entered under its generally used name. The entries are in alphabetical order. The names, and a large number of synonyms for them, are included in the Cross Index, Appendix [illegible].

To Find Data for a Spill

If the spilled substance is known by name, start at the Cross Index. If it is not found, it may be because the name is an unusual synonym or trade name. Proceed as for an unknown spill.

If the spilled substance is not known, use the Categorization, Appendix [illegible], to find which entries most likely include the spill.

Using the Data

Below are some ways in which the Dictionary can be used:

Chemical Formula - a chemist can use this to amplify the description and detection data.

Synonyms - the names of chemicals commonly [illegible] and [illegible] may not recognize a particular name for the spill.

Description - use to predict damage, e.g., if the spill is heavier than water and not highly soluble, bottom life is especially at risk.
Use to help identification of an unknown spill; check the description against observations made at the site.

Toxicity - The toxicity ratings are:
High: toxic threshold below 10 ppm.
Medium: toxic threshold between 10 and 100 ppm.
Low: toxic threshold above 100 ppm.
Use the human effects to estimate safety hazards.
The local toxicity is immediate effects on skin, eyes, mucous membranes, or respiratory tract.
The systemic toxicity is [illegible] by ingestion, inhalation, or skin absorption.
Use the human effects to [illegible].
Use the aquatic toxicity as a guide to biological damage that can be expected, as a check from observed effects, along with the identification of

ABIETIC ACID

$C_{19}H_{29}COOH$ (phenanthrene ring structure)

Synonyms: Sylvic Acid

Description: Derived from pine rosin, of which it is the principal active ingredient. Yellowish, resinous powder. (Sinks); insoluble.

Toxicity:

Local - Moderately irritant.
Systemic - Moderate.
Aquatic - Moderate.
Other - Promotes growth of several types of lactic acid and butyric acid bacteria.

Detection: Prepare a solution (approximately 1%) of bromine in carbon tetrachloride; add a few drops to 2 ml of sample. Positive result: the color of bromine disappears. Unsaturated organic compounds interfere. The powder of abietic acid may be dissolved in an organic solvent (alcohol, benzene, etc.), then tested with bromine; this is a useful test for sediment samples. (1,4). Instrumental analysis: UV. (1,4,6).

ACETALDEHYDE CH_3CHO

Synonyms: Acetic aldehyde, aldehyde, ethanal, ethylaldehyde, paraldehyde.

Description: Very flammable, clear, colorless, liquid. Characteristic pungent odor that smells like fruit in extreme dilution ([illegible] ppm). Explosive vapor. Completely miscible.

Toxicity:

Local - Both liquid and vapor irritate eyes, mucous membranes, and skin.

Systemic - Slight to moderate; large doses of vapor can cause respiratory collapse.

Aquatic - Moderately toxic to fish, invertebrates, flora.

PROTECTIVE CLOTHING AND RESPIRATOR ADVISABLE.

Detection: Commercial detectors are available; sensitivity range is 25 - 1000 ppm. Suppliers include MSA (1 or 2 depending on kit) and [illegible].

ACETAMIDE $CH_3C{:}ONH_2$

Synonyms: Acetic acid amine, ethanamide.

Description: Colorless deliquescent solid. Slight odor. Sinks and dissolves.

Toxicity:

Local: Mild irritant.
Systemic: Low.
Aquatic: Low.
Other: Increases BOD.

Detection:

(1) Mix sample with 1N. 4% hydroxylamine sulfate in 14% sodium hydroxide solution.
(2) Acidify with HCl.
(3) Add several drops of 20% ferric chloride solution.
Positive result: solution (3) turns green in a few minutes. (1,2,4).

ACETANILIDE $C_6H_5\ NH(C{:}OCH_3)$

Synonyms: N-Phenylacetamide.

Description: Shiny white solid (leaflets or powder). Odorless. Stable in air. Slightly burning taste. Sinks, slowly dissolves.

Toxicity:

Local - May be mild irritant.
Systemic - Low to moderate.
Aquatic - Low to moderate.

Detection: See ACETAMIDE (1, 5, 6).

ACETIC ACID H_3CCOOH

Synonyms: Ethanoic acid, glacial acetic acid, vinegar.

Description: Clear, colorless liquid. Freezes at 62^{o}F (concentrated solution). Odor of vinegar. Acid to litmus. Reacts with many minerals to produce metal acetates and mineral acids. Look for corrosion, BOD, and pH effects. Completely miscible.

Toxicity:

Local: Irritant vapors, concentrated solutions can burn eyes, mucous membranes, skin.

Systemic - Dilute solutions are nontoxic, concentrated solutions can burn and corrode tissues.

Aquatic - Dilute solutions are practically harmless, concentrated solutions are corrosive and can severely damage aquatic life. Damage varies with pH.

Other: Dilute solutions can create a BOD problem.

Detection:

(I). High concentrations of any acid or base may be detected with a pH meter or pH indicator paper (e.g. litmus). (1, 3).

(II). Test sample with solution of 5% lanthanum nitrate and 0.01N iodine. Positive result: dark blue precipitate or solution. (1, 5, 6).

ACETIC ANHYDRIDE $(H_3CC:O)_2O$

Synonyms: Acetic oxide, acetyl oxide.

Description: Very refractive liquid. Strong odor of vinegar. Fire hazard: Burns readily. Sinks in water, slowly forming ACETIC ACID. Look for corrosion, pH, and BOD effects.

Toxicity:

Local - Both liquid and vapor are violently irritating and corrosive to eyes, mucous membranes, and skin.

Systemic - Burns and corrodes tissues. See ACETIC ACID for other effects.

Aquatic - Corrosive and toxic to all aquatic life; for toxicity of dilute solutions, see ACETIC ACID.

Detection: See ACETIC ACID.

ACETONE CYANOHYDRIN $(CH_3)_2COHCN$

Synonyms: Methylacetonitrile, hydroxyisobutyronitrile.

Description: Colorless liquid. Floats and readily dissolves. Decomposes readily to yield HYDROCYANIC ACID (liquid and vapor, depending on temperature), which is one of the most toxic substances known.

Toxicity:

Local - May slightly irritate eyes, skin, mucous membranes.
Systemic - See HYDROCYANIC ACID; extremely toxic.
Aquatic - See HYDROCYANIC ACID; extremely toxic.

WEAR RESPIRATOR; PROTECTIVE CLOTHING ADVISABLE.

Detection:

(I). Use only in a well-circulated hood -- extremely toxic hydrogen cyanide gas is evolved. Mix small volume of sample with 3M HCl; test with commercial cyanide kit (see BARIUM CYANIDE). If test is unclear, repeat, using a larger volume of sample.

(II). Place 2 drops of sample in a micro test tube with 2 drops of dilute H_2SO_4. Immediately cover the mouth of the test tube with a disk of filter paper moistened with a drop of the reagent, which is made by mixing equal volumes of solution A and solution B just before use. Solution A is 2.86 g copper acetate in 1 liter of water. Solution B contains 675 ml of saturated benzidine acetate solution plus 525 ml of water. Positive result: the reagent paper turns blue. (1, 9).

ACETONITRILE H_3CCN

Synonyms: Cyanomethane, ethanenitrile, methyl cyanide.

Description: Colorless liquid. Sweet odor, much like ether. Floats and dissolves. Flammable; explosive vapors.

Toxicity:

- Local - May irritate skin.
- Systemic - Low to moderate; avoid breathing the vapors.
- Aquatic - Low.

RESPIRATOR ADVISABLE.

Detection: Commercial liquid and vapor detector kits are available; sensitivity range is 10 - 200 ppm. Suppliers include MSA. Warm samples before using vapor detectors. (1, 5, 6).

ACETOPHENONE $C_6H_5COCH_3$

Synonyms: Acetylbenzene, hypnone, phenyl methyl ketone.

Description: Colorless liquid that freezes at 68°F. Odor of orange blossoms. Sinks; slightly soluble.

Toxicity:

Human and Aquatic - Practically none. Hypnotic in high concentrations.

Detection: Mix sample with a saturated solution of 2,4-dinitrophenylhydrazine in 2N HCl. Positive result: precipitate. (1, 5, 6).

ACETYL BROMIDE H_3CCOBr

Synonyms: none common.

Description: Colorless, fuming liquid. Sinks, but is violently decomposed by water to yield ACETIC ACID and hydrobromic acid. Clouds of acrid fumes may develop.

Toxicity:

Local - Intensely irritating to eyes, mucous membranes, and skin.

Systemic - See ACETIC ACID; hydrobromic acid is very corrosive in concentrated solution, dilute solutions (10% or less) are sedatives.

Aquatic - See ACETIC ACID; the bromide ion is very toxic to many microflora, invertebrates, and fish.

Other - Look for corrosion and pH effects.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING IN REACTION ZONE AND WHERE pH IS LOW.

Detection: Analyze separately for the hydrolysis products, viz. ACETIC ACID and hydrobromic acid. See ACETIC ACID for detection method. Use pH indicator paper or meter to test for acid. (1, 3). Then test for bromide ion as follows. In a test tube, mix 1 ml of sample with 0.2 g PbO_2 and 1 ml of 2N acetic acid. Cover mouth of test tube with filter paper that has been impregnated with a saturated solution of fluorescein in 1:1 ethanol. Positive result: filter paper turns red. Iodides interfere. (1, 4).

ACETYLENE $HCCH$

Synonyms: Ethine, ethyne.

Description: Colorless gas; ethereal odor when pure, but disagreeable odor when impure. Very flammable; the compressed gas is explosive. Slightly soluble.

Toxicity:

Local - None.

Systemic - A simple asphyxiant; high concentrations of inhaled gas are narcotic.

Aquatic - None to low.

Detection: Commercial liquid and vapor detector kits are available; sensitivity range is 3 - 3000 ppm. Suppliers include MSA, Scott/Davis, and Kitagawa. (2, 5, 6).

ACRIDINE

$C_{13}H_9N$ (tricyclic)

Synonyms: Azaanthracene, dibenzopyridine.

Description: Colorless crystalline solid. Sinks; nearly insoluble. Weakly basic; colors litmus blue.

Toxicity:

Local - Strong irritant to skin and mucous membranes.
Systemic - Low.
Aquatic - Reports vary from very low to very high. Highly toxic to some fish.

Detection: Acidify sample with 3M HCl. Positive result: yellow precipitate. (1, 4).

ACRYLIC ACID $H_2C:CHCOOH$

Synonyms: Propenoic acid, vinylformic acid.

Description: Corrosive, fuming liquid. Acrid odor. Just sinks, miscible with water. Polymerizes readily in the presence of oxygen, but polymerization inhibitors (such as HYDROQUINONE) are often added; the polymer is a clear plastic.

Toxicity:

Local - Strongly irritating.
Systemic - Low.
Aquatic - Moderate to low.

Detection: Mix sample with 5 ml of 4.4% mercuric acetate and 0.5% acetic acid in 6:4 water-dioxane solution. Positive result: precipitate, which redissolves when mixed with 30 ml of 0.02M EDTA solution. (1, 5).

ACRYLONITRILE $H_2C{:}CHCN$

Synonyms: Cyanoethylene, Fumigrain, propenenitrile, Ventox, vinyl cyanide.

Description: Explosive, flammable, volatile liquid. Colorless when fresh; may slowly turn yellow in light. Slight biting odor. May polymerize spontaneously in light. Floats. Evaporates quickly, dissolves slowly.

Toxicity:

Local - Extremely irritating vapor.
Systemic - Moderate to high; similar to HYDROCYANIC ACID.
Aquatic - Moderate to high.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING

Detection: Commercial liquid and vapor detector kits are available; sensitivity range is [illegible] - 500 ppm. Suppliers include MSA, Scott/Davis, and Kitagawa.

ADIPIC ACID $HOOC(CH_2)_4COOH$

Synonyms: Butanedicarboxylic acid, hexanedioic acid.

Description: Colorless solid that sinks and slowly dissolves in water. Acid to litmus.

Toxicity:

Human: Slight, if any.
Aquatic: Moderate.
Other: Look for BOD effect in still water.

Detection: No satisfactory method for detection at water's edge.

(I). For improvised field laboratory (e.g. in motel room, with equipment available), esterify sample, then add p-nitrobenzyl chloride to water. Heat sample. Positive result: an insoluble derivative will slowly form and precipitate from solution. (1, 9).

(II). For instrumental analysis in improvised lab, use GC with hydrophobic column packing. (2, 3, 4).

(III). In areas of high concentration, test water for acidity with pH indicator paper or pH meter. (1, 9).

(IV). In very pure water, where no other acids or bases of low molecular weight are present in significant quantity, consider using potentiometric titration with 0.1N NaOH, using thymol blue as indicator. (1, 9).

ADIPONITRILE $CN(CH_2)_4CN$

Synonyms: Adipyl dinitrile, 1,4-dicyanobutane, tetramethylene cyanide, tetramethylene dicyanide.

Description: Colorless liquid; almost no odor. Soluble in water, dissolving slowly.

Toxicity:

Local: Vapor and liquid are mild irritants.
Systemic: Moderately toxic by all routes; absorbed through intact skin.
Hazard: Moderate to low.

PROTECTIVE CLOTHING AND RESPIRATOR ADVISABLE.

Detection: No satisfactory method for detection at water's edge. An improvised mobile field laboratory is the best one can hope for. The following methods require at least an improvised laboratory.

(1) Use GC with hydrophobic column. (2,3,4).
(2) (a) Subject sample to vigorous hydrolysis.
(b) Render solution basic with NaOH, then heat to liberate AMMONIA, which may be detected by any of several commercial kits, simple wet-chemical methods, or [illegible]. This method only detects the ammonium salt produced by hydrolysis. (2,7,8). To detect the adipic acid moiety, see methods I and II under ADIPIC ACID. Rating will depend on method chosen.

ALLYL ALCOHOL $H_2C{:}CHCH_2OH$

Synonyms: Propenol, propenyl alcohol, vinyl carbinol.

Description: Colorless flammable liquid. Sharp, biting odor similar to mustard. Floats; completely miscible with water.

Toxicity:

Local - Very irritating vapor and liquid. Severe burns.
Systemic - Moderate; burns respiratory tract.
Aquatic - Moderate to high.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Mix sample with small amount of silver nitrate. Positive result is a precipitate that redissolves when an excess of concentrated silver nitrate solution is added. (1, 5).

ALLYL CHLORIDE $CH_2=CHCH_2Cl$

Synonyms: [illegible]

Description: Clear to strawish, [illegible] liquid. Disagreeable, pungent odor. Floats on water; slightly soluble. A toxic and explosive layer of vapor [illegible] the water's surface. Very flammable.

Hazards:

Local - Strongly irritant vapor and liquid.
Systemic - Moderate.
Aquatic - Toxicity varies from very low to very high.
Highly toxic to some fish.

FIELD DETECTION AND PROTECTIVE CLOTHING

Detection: Add to [illegible] colored range of a saturated solution of [illegible] in concentrated HCl. Positive result [illegible]

ALUMINUM FLUORIDE [illegible]

Synonyms: Aluminum [illegible]

Description: White solid. Soluble in water; slightly soluble [illegible] [illegible]

Hazards:

Health: [illegible]
Flammability: [illegible]
Reactivity: [illegible]

Analysis: The aluminum and fluoride components must be detected separately. To detect aluminum, see ALUMINUM SULFATE. [illegible] A [illegible] test for fluoride [illegible] a reagent composed of 0.1 g alizarin [illegible] in [illegible] ethanol, and 0.1 g of zirconyl chloride in one pint of water. This reagent is [illegible] Add [illegible] to reagent. Fluoride [illegible] in a pale yellow [illegible]

ALUMINUM SULFATE $Al_2(SO_4)_3$

Synonyms: Alumogenite, cake alum, patent alum.

Description: Shiny white solid. Sinks and dissolves readily, forming an acid solution. Mildly antiseptic and detergent.

Toxicity:

Human - Low.
Aquatic - Low to moderate.

Detection: The aluminum and sulfate components must be separately detected. To detect aluminum, add dilute NH_4OH to sample. Positive result: a gelatinous white precipitate that is insoluble in an excess of NH_4OH. (1,4,6). Commercial kits are available for detecting sulfate in the range 0-500 ppm. Hach Chemical is one supplier. (1,4,6). Commercial kits are also available for detecting aluminum; sensitivity range is 0.02 to 1 ppm. Suppliers include Hellige. (2,5,6). There are several commercial kits for detecting sulfate from 1 to 500 ppm. Suppliers include Hach, Hellige, and Lamotte. (1,4,6).

AMINO ETHYL ETHANOL AMINE $H_2NCH_2CH_2NHCH_2CH_2OH$

Synonym: Hydroxyethylethylenediamine.

Description: Clear, colorless hygroscopic liquid with mild ammoniacal odor. Just sinks; dissolves readily, giving a basic solution.

Toxicity:

Local - Very irritating; may burn skin.
Systemic - Low.
Aquatic - (Low.)

PROTECTIVE CLOTHING ADVISABLE.

Detection: There is no specific and sensitive method for use at water's edge. Test pH in area of concentrated spill, using pH indicator paper or pH meter (1, 3). Test for alcohol as follows. Combine 2 ml of sample with 5 ml of reagent (a 10% solution of ceric ammonium nitrate in 2N nitric acid). Positive result: yellow to red solution. (1, 3). Test for secondary amine as follows. Prepare reagent by dissolving 0.5 g $NiCl_2$ hexahydrate in 200 ml of water. While shaking, add carbon disulfide to slight excess. Just before testing sample, add 2 ml concentrated NH_4OH to 5 ml of reagent. Then add 2 ml of sample. Positive result: a well-defined precipitate. (1, 3).

AMMONIA

NH_3

Synonyms: Ammonia gas, anhydrous ammonia, liquefied ammonia.

Description: Colorless gas or colorless compressed, liquefied gas that dissolves readily in water, giving a strongly basic solution. The gas, the compressed gas, and the water solution have a characteristic sharp, biting odor that is noticeable in great dilution.

Toxicity:

Local: All forms are very irritating to the eyes and mucous membranes, somewhat irritating to skin.

Systemic: Slight.

Aquatic: High to moderate.

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE.

Detection: There are several commercial kits for detecting ammonia or the ammonium ion. Commercial sources include MSA, Scott/Davis, Kitagawa, Lamotte, Hellige, and Hach; sensitivity range is 0.02-1500 ppm. (2,4,5). A simple, less sensitive method is to make the sample basic by adding NaOH, then heat to steaming, then test the vapor with wetted pH paper, which should register pH 11, approximately. (1,4). A more specific method is to mix the sample with Nessler's reagent (dissolve 20 g of KI and 12 g of HgI_2 in 200 ml of water, then add 260 ml of 10% KOH). Positive result: brown precipitate.

AMMONIUM ACETATE $H_3CCOONH_4$

Synonyms: Acetic acid ammonium salt, spirit of Mindererus.

Description: White deliquescent solid. Slight odor of vinegar. Sinks; very soluble, giving a colorless solution that is acid to litmus when very concentrated.

Toxicity:

Human: Slight.
Aquatic: Moderate.

Detection: The ammonium and acetate components must be separately analyzed. To detect ammonium, see methods under AMMONIA. To detect acetate, test as follows: (1) Check acidity of sample, if acid, neutralize with $ZnCO_3$. (2) Then add several drops of 0.5M ferric chloride. Positive result: sample solution turns brown when the ferric chloride is added, and a precipitate forms upon heating. Thiocyanates, tartrates, and iodides interfere. (1,5).

A quick presumptive test is to acidify a large quantity of the sample with sulfuric acid, then heat to boiling; positive result is the odor of vinegar. (1,5)

Alternatively, acidify the sample, then use the lanthanum test for ACETIC ACID. See ACETIC ACID.

AMMONIUM CARBONATE. Mixture of NH_4HCO_3 and NH_4COONH_2

Synonyms: Crystal ammonia, ammonium sesquicarbonate, hartshorn.

Description: A mixture of ammonium acid carbonate (ammonium bicarbonate) and ammonium carbamate. White solid that is unstable in air. The carbamate is converted to the acid carbonate. Strong odor of ammonia; sharp ammoniacal taste. Sinks and dissolves slowly.

Toxicity:

Human : Low.
Aquatic : Low to moderate.

Detection: The ammonium and carbonate components must be separately analyzed. See AMMONIA for methods applicable to ammonium.

To detect carbonate, add dilute HCl to a large volume of sample; bubbles of carbon dioxide will form, and heating will increase the rate of its evolution. (1, 5).

Several commercial kits are available for detecting CO_2. Sources include Kitagawa, MSA, and Scott/Davis. (2, 5, 6).

AMMONIUM CHLORIDE NH_4Cl

Synonyms: Amchlor, ammonium muriate, Darammon, sal ammoniac, salmiac.

Description: White solid, somewhat hygroscopic. Odorless. Cooling, saline taste. Very soluble in water, cooling the water as it dissolves. Slightly acid in solution. Reacts with the alkalis and their carbonates.

Toxicity:

Human - Practically none.

Aquatic - Reports vary from high to moderate.

Detection: The ammonium and chloride components must be separately analyzed. See AMMONIA for methods applicable to ammonium.

Commercial kits are available for chloride detection; sensitivity range is 17 - 1000 ppm. Suppliers include Hellige. (2,3,6).

Alternatively, test for chloride as follows. (1) If ferricyanides, ferrocyanides, thiocyanates, bromides, or iodides are significant in the sample, they will interfere with the test; remove this interference by boiling the sample with a mixture of 6M HNO_3 and 0.5M K_2CrO_4. (2) Mix sample with 0.5M $AgNO_3$; a white precipitate is positive. (3) Collect precipitate and mix with 6M NH_4OH; redissolution of precipitate is further positive proof. (4) Acidify solution (3) with 6M HNO_3; reprecipitation is further proof. (2,4,6).

AMMONIUM CHROMATE $(NH_4)_2CrO_4$

Synonym: Neutral ammonium chromate.

Description: Yellow crystalline solid. Sinks and dissolves, giving an alkaline yellow solution.

Toxicity:

Local - Strongly irritating.
Systemic - (Low to moderate)
Aquatic - Low to moderate.

Detection: The ammonium and chromate components must be separately analyzed. See AMMONIA for methods applicable to ammonium. There are several commercial chromate detectors; sensitivity is 0.1 - 600 ppm. Suppliers include Hach, Hellige, Lamotte, and Taylor. (2,4,6). Alternatively, detect chromate by either of the following methods.

(I). Neutralize sample. Then add a small quantity of concentrated lead nitrate solution. Positive result: bright yellow or orange precipitate. (2,5,6).

(II). Acidify sample with 6M HNO_3, drop by drop. Then add sequentially 4 ml of ether and 2 ml of 3% H_2O_2. Positive result: ether layer turns deep blue. Dichromates also give positive result. (1,5,6).

AMMONIUM DICHROMATE $(NH_4)_2Cr_2O_7$

Synonym: **Ammonium bichromate.**

Description: **Bright scarlet crystalline solid. Flammable. Odorless. Sinks; very soluble in water, giving a bright orange acidic solution.**

Toxicity:

Local - Strong irritant; may ulcerate skin wounds.
Systemic - Low to moderate.
Aquatic - Moderate.

Detection: The ammonium and dichromate components must be separately analyzed.

See AMMONIA for methods applicable to ammonium.

See AMMONIUM CHROMATE for methods applicable to dichromate.

AMMONIUM FERRICYANIDE $(NH_4)_3Fe(CN)_6$

Synonym: Ammonium hexacyanoferrate (III).

Description: Red crystalline solid. Sinks and dissolves freely in water. Tends to decompose in strong light, losing ammonia.

Toxicity:

Human - Low.
Aquatic - Low to moderate.

Detection: The ammonium and ferricyanide components must be separately analyzed.

See AMMONIA for methods applicable to ammonium. Test for ferricyanide as follows. Acidify sample with 6M HCl. Then add 1M ferrous sulfate solution. Positive result: deep blue precipitate. (2, 5, 6).

AMMONIUM FERROCYANIDE $(NH_4)_4Fe(CN)_6$

Synonym: Ammonium hexacyanoferrate (II).

Description: Yellow to greenish-yellow crystalline solid. Turns blue in air. Sinks and dissolves freely in water. Loses ammonia on exposure to air and light.

Toxicity:

Human - Low.
Aquatic - Low to moderate.

Detection: The ammonium and ferrocyanide components must be separately analyzed.

See AMMONIA for methods applicable to ammonium. Test for ferrocyanide as follows. Acidify sample with 6M HCl. Then add 0.5M ferric chloride solution. Positive result: deep blue precipitate. (2,5,6).

AMMONIUM NITRATE NH_4NO_3

Synonyms: Nitrate of ammonia, Norway saltpeter.

Description: White, hygroscopic, deliquescent solid. Odorless. Sinks and dissolves easily.

Toxicity:

Human - Low.
Aquatic - Moderate to low.
Other - Promotes growth of algae and plants.

Detection: The ammonium and nitrate components must be separately analyzed.

See AMMONIA for methods applicable to ammonium.

Commercial nitrate kits are available; sensitivity range is 0.3 - 100 ppm. Suppliers include Hach, Hellige, Lamotte, and Taylor. (2,5,6).

AMMONIUM PERCHLORATE NH_4ClO_4

Synonyms: AP, APC.

Description: White, crystalline solid. Sinks and dissolves freely. A strong oxidizing agent that reacts easily with organic material.

Toxicity:

Local - Skin irritant.
Systemic - (Low.)
Aquatic - (Low.) Damaging to plants.

Detection: The ammonium and perchlorate components must be separately analyzed.

See AMMONIA for methods applicable to ammonium.

Detect perchlorate as follows. Mix sample with 0.3% of aqueous methylene blue. Positive result: a violet precipitate that is soluble in hot water. Iodides interfere, but they can be removed beforehand by adding sufficient quantitites of freshly precipitated silver oxide, followed by filtering; the filtrate will be free of iodides. (2, 5, 6).

AMMONIUM PEROXYDISULFATE $(NH_4)_2S_2O_8$

Synonym: Ammonium persulfate.

Description: White, crystalline solid. Sinks and dissolves, gradually losing oxygen. Bleaches.

Toxicity:

Local - (Mild irritant).
Systemic - (Low).
Aquatic - (Moderate).

Detection: The ammonium and peroxydisulfate components must be separately analyzed.

See AMMONIA for methods applicable to ammonium. Detect peroxydisulfate as follows. Add sample to a solution of 2% benzidine in dilute acetic acid. Positive result: mixture turns blue. Chromates, permanganates, and hypohalites interfere. (1, 5, 6).

AMMONIUM PHOSPHATE

$NH_4H_2PO_4$ and $(NH_4)_2HPO_4$

Synonyms: Monobasic and dibasic ammonium phosphate, primary and secondary ammonium phosphate, Fyrex.

Description: Both the mono- and dibasic salts are odorless, white crystalline solids. Both sink and dissolve readily in water. The dibasic salt is weakly alkaline; the monobasic salt is weakly acid. In water solution they hydrolyze to yeild ammonium hydroxide. See AMMONIA.

Toxicity:

Human - Low.
Aquatic - Moderate to low.
Other - Promoted growth of algae and plants.

Detection: The ammonium and phosphate components must be separately analysed.

See AMMONIA for methods applicable to ammonium. Commercial kits are available for detecting phosphates; sensitivity range is 0.05 - 120 ppm. Suppliers include Hach, Hellige, Lamotte, and Taylor. (2, 5, 6). A good qualitative test for phosphates is to boil a mixture of 2 ml of sample, 2 ml of concentrated HNO_3, 1 ml of NH_4NO_3, and 2 ml of ammonium molybdate. Positive result is a yellow precipitate. For further confirmation, add 1 ml of 0.5% aqueous hydroquinone and 1 ml of 20% sodium sulfite; the mixture will turn blue if the test is positive. (2, 5, 6).

AMMONIUM PICRATE $C_6H_2(NO_2)_3ONH_4$

Synonyms: Ammonium carbazotate, ammonium picronitrate.

Description: Yellow crystals with sharp, objectionable taste. Sinks and dissolves in water. Very reactive with metals. Explosion hazard when dry.

Toxicity:

Local - Very irritating; a strong allergen.
Systemic - (Moderate).
Aquatic - (Moderate).

Detection: The ammonium and picrate components must be separately analyzed.

See AMMONIA for methods applicable to ammonium. Test for picrate by shaking sample with a 10% ethanolic solution of triethylamine. Positive result: picrates precipitate. (1, 4, 6).

AMMONIUM SULFATE $(NH_4)_2SO_4$

Synonyms: None common.

Description: White, crystalline solid. Technical grades are off-white to brownish gray. Sinks and dissolves in water. Water solution is very weakly acid.

Toxicity:

Human - (Low to none: has been used in medicine and as food additive).

Aquatic - Reports vary widely. Probably low to moderate.

Detection: The ammonium and sulfate components must be separately analyzed.

See AMMONIA for methods applicable to ammonium.

See ALUMINUM SULFATE for detection of sulfate.

AMMONIUM SULFIDE

NH_4HS

N. B. True ammonium sulfide, $(NH_4)_2S$, is stable only in the absence of moisture and below 0°C. The ammonium sulfide of commerce is largely the hydrosulfide (also called the bisulfide).

Description: Yellow crystalline solid. Sinks and dissolves readily in water, making a yellow solution whose color grows more intense with aging. The water solution is strongly alkaline. Both the crystals and the solution have the mixed odor of ammonia (sharp and biting) and hydrogen sulfide (like rotten eggs).

Toxicity:

Local - Strong irritant.
Systemic - (Low). Toxic by skin penetration.
Aquatic - Moderate.

Detection: The ammonium and sulfide components must be separately analysed.

See AMMONIA for methods applicable to ammonium. Detect sulfide by any of the following methods.

(I). There are commercially available kits for detecting sulfide in water (0.2 - 20 ppm). Suppliers include Hellige and Lamotte. (2, 5, 6).

(II). Acidify the sample with 3M HCl to form H_2S gas, which may be detected by several commercially available kits. Suppliers include MSA, Scott/Draeger, and Kitagawa.

(III). There is a simple qualitative test for sulfide. Mix sample with 6M NH_4OH, then add 0.5M tetraminezinc nitrate solution. Positive result: white precipitate. (1, 5, 6).

AMMONIUM THIOCYANATE NH_4SCN

Synonyms: Ammonium rhodanide, ammonium sulfocyanide, ammonium sulfocyanate.

Description: Colorless, deliquescent, crystalline solid. Sinks and dissolves freely in water.

Toxicity:

Human - Slightly toxic by ingestion; may have damaging side effects.
Aquatic - Moderate.

Detection: The ammonium and thiocyanate components must be separately analyzed.

See AMMONIA for methods applicable to ammonium. Test for thiocyanate as follows. Acidify sample with 6M HCl, then add 0.5M $FeCl_3$ solution. Positive result: solution turns blood red. (2, 5, 6).

AMYL ACETATE

$H_3CCOOC_5H_{11}$

N. B. both the _n_-amyl and isoamyl esters are commercially known.

Synonyms: Amyl acetic ester, banana oil, pear oil, pentacetate, penthanol acetate.

Description: Colorless neutral liquid. Pleasant odor rather like bananas or pears. Floats on water; very slightly soluble. A layer of vapor will tend to accumulate at the water's surface. Risk of fire or explosion on warm days.

Toxicity:

Local - Mildly irritating to mucous membranes on exposure to the vapor.
Systemic - (Low).
Aquatic - Moderate.

Detection: There is no satisfactory method for detecting this substance at water's edge.

Either of the following methods may be used in an improvised laboratory (e.g. a motel room with equipment available). Instrumental method of choice: GC with hydrophobic column. The ester can be saponified in about one hour to give ACETIC ACID and PENTANOL.

A qualitative test for pentanol is to combine 5 ml of saponification product with 5 ml of reagent (a 10% solution of ceric ammonium nitrate in 2N HNO_3). Positive result: solution turns yellow to red. Other alcohols interfere. (1, 4).

ANILINE

$C_6H_5NH_2$

Synonyms: Aminobenzene, aminophen, phenylamine, red oil (a mixture of aniline and toluidine).

Description: Oily liquid; colorless when fresh. Darkens on exposure to air and light. Sinks in water, gradually dissolving. Characteristic sharp odor and burning taste. Can be smelled in concentrations below 1 ppm. Very slightly alkaline.

Toxicity:

Local - Slight irritant; DANGER: Toxic by skin absorption.

Systemic - Highly toxic by ingestion, inhalation, or absorption through intact skin.

Aquatic - Moderate.

N. B. Soluble aniline derivatives, such as the hydrochloride, have higher aquatic toxicity than aniline.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Commercial liquid and vapor kits for detecting aniline are sensitive to 2 - 10 ppm. Scott/Davis is one supplier. (2, 5, 6).

ANIONIC SURFACTANTS $RArSO_3Na$

Includes: A large family of anionic detergents and wetting agents, including the alkyl benzene sulfonate (ABS) detergents, many of which are nonbiodegradable. Dozens of brand names, and the principal ingredient of many commercial cleaning agents: This is the largest family of synthetic detergents.

Description: White to pale yellow solid, available as crystals, flakes, powders, and solutions. They sink and dissolve readily, giving a characteristic opalescent soapy solution.

Toxicity:

Local - May dry and irritate skin; some can cause burns.
Systemic - Low.
Aquatic - Reports vary: sometimes High, usually Low.
Other - Can cause extensive foaming and sudsing. Biodegradability varies; some are very persistent.

Detection: Shake 5 ml of sample with 10 ml of chloroform and 25 ml of methylene blue reagent (50 g Na_2SO_4, 6.8 ml concentrated H_2SO_4, and 30 ml of 0.1% methylene blue solution in 1 liter of water). Positive result: blue chloroform layer. (1,4). Commercial test kits are available; Hach Chemical Company is one supplier.

ANTIMONY POTASSIUM TARTRATE

$C_4H_4KO_7Sb$

Synonyms: Potassium antimonyl tartrate, tartar emetic, tartrated antimony, tartarized antimony.

Description: Transparent, whitish, crystalline solid. Sweetish, metallic taste. Sinks and dissolves in water, giving a slightly acid solution.

Toxicity:

Human - Low to moderate by ingestion.
Aquatic - Moderate.
N. B. All soluble antimony compounds are moderately toxic to aquatic life.

Detection: The Sb, K, and tartrate components must be separately analyzed.

Detect Sb by either of the following methods.

(I). Mix sample with 0.02% rhodamine B in 1:10 HCl. Positive result: violet solution or precipitate. (2, 5, 6).

(II). Acidify sample with 3M HCl, then add a 5% solution of ammonium sulfide. Positive result: orange precipitate. (2, 5, 6).

See POTASSIUM CHROMATE for methods applicable to K. To test for tartrates, add acid potassium permanganate (1N $KMnO_4$ in 5% H_2SO_4) to sample; carbon dioxide and FORMIC ACID will be formed from tartrates. See AMMONIUM CARBONATE for methods applicable to CO_2; see FORMIC ACID for its detection method.

Many common natural conditions lead to precipitation of antimony compounds from solution. Surface samples of sediment may supply important evidence. Boil these samples in aqua regia, filter, then test the filtrate by either of the methods above.

ANTIMONY TRICHLORIDE $SbCl_3$

Synonyms: Antimonous chloride, antimony chloride, butter of antimony, caustic antimony.

Description: Colorless, transparent, crystalline solid. Fumes slightly in air. Sinks; gradually hydrolyzes to form antimony oxychloride ($SbOCl$), which settles as a powdery white precipitate. (In salt water, where the chloride ion is prevalent, the oxychloride may not form.) HYDROCHLORIC ACID is formed by hydrolysis of the trichloride.

Toxicity:

Local - Strongly irritant; corrodes skin.
Systemic - Low to moderate by ingestion.
Aquatic - Moderate.
Other - In addition to the toxic effects of the antimony ion, look for pH effects due to HYDROCHLORIC ACID.

Detection: The Sb and Cl components must be separately analyzed.

See ANTIMONY POTASSIUM TARTRATE for Sb methods.
See AMMONIUM CHLORIDE for Cl methods.

ANTIMONY TRIFLUORIDE SbF_3

Synonyms: **Antimony fluoride, antimonous fluoride.**

Description: **White to gray deliquescent crystalline solid.**
Sinks and dissolves easily in water, readily forming slightly soluble compounds.

Toxicity:

Local - Very irritating.
Systemic - High.
Aquatic - Moderate. Look for damage to plants.

Detection: The Sb and F components must be separately analyzed.

See ANTIMONY POTASSIUM TARTRATE for Sb methods.
See ALUMINUM FLUORIDE for F methods.

ANTIMONY TRIOXIDE Sb_2O_3

Synonyms: Antimony white, antimony oxide, diantimony trioxide, flowers of antimony, Senarmontite, Valentinite, Exitelite, Weisspiessglanz.

Description: Odorless, white, crystalline solid. Sinks, dissolving slowly.

Toxicity:

Human - Low.
Aquatic - Moderate.

Detection: Only the Sb component need be detected. To detect Sb in solution, see ANTIMONY POTASSIUM TARTRATE. To test sediments and solids for Sb, first dissolve them with 6M HCl, then follow the procedures given for Sb under ANTIMONY POTASSIUM TARTRATE.

BARIUM CHLORIDE

$BaCl_2$

Synonyms: None common.

Description: White crystalline solid. Very bitter salty taste. Sinks and dissolves readily in water. Water that is rich in CO_2, sulfate, phosphate, or several other common anions will gradually precipitate barium from solution as a white powder, or make a cloudy white suspension of the precipitate.

Toxicity:

Human - Moderate by ingestion.
Aquatic - Moderate. Toxic to plants and animals.
N. B. Soluble barium compounds gradually precipitate from water that is rich in CO_2, sulfate, phosphate, etc. The white, powdery precipitate may become a milky suspension in turbulent water. Reports on the aquatic toxicity of Ba compounds vary widely: Most are moderately toxic, but reports of very high and rather low toxicity are not unknown.

Detection: The Ba and Cl components must be separately analyzed. See AMMONIUM CHLORIDE for methods applicable to Cl.

There are several qualitative methods for detecting Ba; the third method is the most specific, and method (IV) is essential for methodological validity.

(I). Mix the sample with a solution of sodium sulfate or sodium carbonate. Positive result: white precipitate. Several metallic ions interfere. (1, 5).

(II). Mix the sample with a solution of potassium chromate. Positive result: heavy yellow precipitate. Several metallic ions interfere. (1, 5).

(III). Mix 0.5 ml of sample with 1 ml of cold saturated potassium permanganate and 1 ml of 1N H_2SO_4. Immediately begin adding saturated aqueous SO_2 solution drop by drop until the purple solution is decolorized. Let stand. Positive result: purple precipitate. Only lead interferes. (2, 5).

(IV). To test solid materials for Ba, dissolve the solids in 3M HCl, filter the solution, and discard the undissolved residue. Test the filtrate for Ba by any of the methods above. Because many conditions lead to the precipitation of Ba from solution, it is important to assay solids taken from bottom surfaces and suspended solids from suspected waters.

BARIUM CYANIDE $Ba(CN)_2$

Synonyms: None.

Description: White crystalline solid. Decays slowly in air, liberating fumes and vapors of HYDROCYANIC ACID, one of the deadliest poisons. Sinks and dissolves freely.

Toxicity:

Human Highly toxic by ingestion. DANGER: Vapors of hydrogen cyanide are released from $Ba(CN)_2$ solutions.

Aquatic - Highly toxic, see HYDROCYANIC ACID.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: The Ba and CN components must be separately analyzed.

See BARIUM CHLORIDE for methods applicable to Ba.

Two methods are given for detecting CN. Method (I) is very dangerous, because gaseous hydrogen cyanide may be evolved; this gas is a VIOLENT POISON. Use method (I) only if a well-circulated hood is available. Method (II) is more cumbersome, but it is safe, and does not require elaborate safety precautions.

(I). Acidify a very small quantity of sample with HCl to form HYDROCYANIC ACID. Several commercial kits (sensitivity is 0.05 - 100 ppm) are available for detecting HCN. Suppliers include Hach, Kitagawa, Lamotte, and Scott/Davis. (2,3,6).

(II). Mix 0.5 ml of sample with 1 ml of 2M NaOH and 1 ml of $FeSO_4$, then heat to boiling. Let this solution cool. Then acidify with 6M HCl. Finally, add 0.5 ml of 0.5M $FeCl_3$ solution. Positive result: deep blue precipitate. (2,5).

BARIUM HYDROXIDE $Ba(OH)_2$

Synonyms: Barium hydrate, caustic baryta.

Description: Transparent white crystalline solid. Water solubility varies with the degree of hydration in the crystal. Hydrated forms readily absorb carbon dioxide from the air, and are rapidly converted to barium carbonate, which is practically insoluble. The water solution is very alkaline. The hydroxide sinks before dissolving.

Toxicity:

Human - Varies with the solubility of the hydroxide: insoluble forms are slightly toxic; soluble forms are very toxic.

Aquatic - Low to high, depending on solubility. Acidic water leads to increased solubility except where soluble sulfates are present.

Detection: Only the Ba component need be analyzed. See BARIUM CHLORIDE for suggested methods.

BARIUM NITRATE $Ba(NO_3)_2$

Synonyms: None common.

Description: Shiny white crystalline solid. Sinks and dissolves freely. Strong oxidizing agent; reacts with organic matter.

Toxicity:

Human - High

Aquatic - Moderate to high. More toxic to plants than to animals.

Detection: The Ba and NO_3 components must be analyzed separately.

See BARIUM CHLORIDE for methods applicable to Ba.
See AMMONIUM NITRATE for methods applicable to NO_3.

BENZENE C_6H_6

Synonyms: Benzol, coal naphtha, coaltar distillate (or light oil or oil), light oil, phene, phenyl hydride, cyclohexatriene.

Description: Clear, colorless, refractive, flammable liquid that freezes at 42°F. Industrial grades may be yellowish. Characteristic aromatic odor. Floats on water; very slightly soluble.

Toxicity:

Local - Mild liquid and vapor irritant.
Systemic - Practically nontoxic, but large doses (by ingestion or inhalation) can be fatal.
Aquatic - Reports vary widely. High.

PROTECTIVE CLOTHING AND RESPIRATOR ADVISABLE.

Detection: There are several commercially available kits for detecting benzene as a liquid or a gas. Suppliers include Davis, Kitagawa, MSA, and Scott/Draeger. Sensitivity range is 5-400 ppm. (2, 5, 6).

Alternatively, test for unsaturation by either of the following methods.

(I). Test water samples by adding several drops of 1% potassium permanganate. Positive result: the purple permanganate solution is decolorized; bleaching agents and readily oxidizable substances interfere. (1, 3).

(II). Where there is a distinct organic phase in the sample, separate this phase and add to it several drops of bromine in carbon tetrachloride (approximately 1%). Positive result: the reddish brown bromine solution is decolorized; readily oxidizable substances interfere. (1, 3).

BENZOIC ACID C_6H_5COOH

Synonyms: Benzenecarboxylic acid, carboxybenzene, phenylformic acid.

Description: White crystalline solid. Odor of almond oil. Sinks in water; slightly soluble. Water solutions are acidic.

Toxicity:

Local - Mildly irritating to eyes, mucous membranes, skin.
Systemic - Low.
Aquatic - Reports vary widely, from low to high.
Other - Look for toxic effects in phytoplankton.
N. B. Metallic salts of benzoic acid (benzoates) are common articles of commerce. Sodium benzoate (benzoate of soda) is one of the most common preservatives used in the food industry; it is more soluble and more toxic than benzoic acid.

Detection: Because this acid is not very soluble, pH is of limited utility in presumptive detection. Suspect solids may be dissolved in hot alcohol, then tested as follows: this presumptive test may be used for all soluble benzoates. Neutralize the sample with 3N NaOH, then mix with 0.5M $FeCl_3$ solution. Positive result: salmon color. (1, 4, 6).

BENZONITRILE

C_6H_5CN

Synonyms: Phenyl cyanide, cyanobenzene.

Description: Colorless flammable oil. Odor of almonds; sharp taste. Usually sinks; may float. Slightly soluble.

Toxicity:

Local - Mildly irritating.
Systemic - Low to moderate.
Aquatic - Moderate.

Detection: There is no satisfactory method for detection at water's edge. In an improvised laboratory (e.g., a motel room, with equipment available), the nitrile could be subjected to vigorous hydrolysis to yield BENZOIC ACID and an ammonium salt. See BENZOIC ACID for suitable detection methods. GC and UV could also be used in an improvised laboratory. To detect the ammonium salt, mix with NaOH to render the solution basic, then heat to liberate gaseous AMMONIA. See AMMONIA for suitable detection methods.

BENZOYL CHLORIDE

C_6H_5COCl

Synonym: Benzene carbonyl chloride.

Description: Transparent, colorless, fuming, pungent liquid. Vapor causes tears. Heavier than water, but decomposes on contacting water into BENZOIC ACID and HYDROCHLORIC ACID.

Toxicity:

Local - Very irritating to eyes, skin, and mucous membranes. The vapor is a lacrimator; the liquid is corrosive and can cause skin burns.

Systemic - Low to moderate: See BENZOIC ACID and HYDROCHLORIC ACID.

Aquatic - Moderate: See BENZOIC ACID and HYDROCHLORIC ACID.

Other - Look for corrosion and pH effects.

Detection: See BENZOIC ACID and HYDROCHLORIC ACID for suitable detection methods.

BENZYLAMINE $C_6H_5CH_2NH_2$

Synonyms: Aminotoluene, moringine, phenylmethylamine.

Description: Colorless to light amber liquid. Floats; mixes easily with water. Combustible. Strongly alkaline.

Toxicity:

Local - Very strong irritant.
Systemic - (Moderate)
Aquatic - Moderate.

PROTECTIVE CLOTHING AND RESPIRATOR ADVISABLE.

Detection: Extract 15 ml of sample with 5 ml of ether. Decant the ether supernatant, and add to it 10 ml of 1% ethanolic p-nitrobenzaldehyde solution;(CAUTION: ETHER EXTREMELY FLAMMABLE.) warm in boiling water for 5 minutes. Then add 2 ml of 2N alcoholic KOH. Positive result: solution turns pink or red. (1, 5, 6).

BERYLLIUM SALTS $BeCl_2$, $Be(NO_3)_2$, $BeSO_4$ etc.

Description: Most beryllium salts are white to faintly yellow, deliquescent, crystalline solids. They sink and dissolve readily, often giving strongly acidic solutions (especially the chloride).

Toxicity:

Local - Extremely irritating to skin, eyes, and air passages; often cause contact ulcers, dermatitis, eye burns.
Systemic - High, especially by inhalation.
Aquatic - High.

Detection: Mix 1 ml of sample with 1 ml of 25% KCN solution and 2 ml of 0.025% of p-nitrophenylazoresorcinol in 0.1N NaOH. This solution must not be more than 3 days old. Positive result: solution turns pink or red. (1, 5).

BORANES BH_3, $(BH_3)_n$, B_nH_m

Includes: Diborane, decaborane.

Description: A series of boron hydrides, ranging from gases to crystals. This series is known up through $B_{20}H_{46}$. Several (especially the lower members of the series, such as gaseous diborane) are unstable and react violently with water to form hydrogen and BORIC ACID. Others, such as decaborane, are very slightly soluble crystals that float on water.

Toxicity:

Local - The lower boranes are irritant.
Systemic - See BORIC ACID.
Aquatic - See BORIC ACID.

Detection: The unstable lower boranes react with water to form BORIC ACID. See BORIC ACID for suitable detection methods. The more stable boranes can be hydrolyzed in acid to form BORIC ACID.

BORIC ACID

H_3BO_3

Includes the common borates, such as sodium borate (borax), potassium borotartrate (cream of tartar), ammonium borate, calcium borate, and aluminum borate.

Synonyms: Boracic acid.

Description: Boric acid and the common borates are white crystalline solids. All but the calcium and aluminum salts are very soluble in water; the calcium and aluminum salts are practically insoluble. The soluble borates may give a fine white precipitate or suspension of calcium borate in hard water, and the precipitate may cause a persistent hazard, particularly to plants.

Toxicity:

Human - Slight.

Aquatic - Very slightly toxic to fish; highly toxic to plants. In hard water, soluble borates may give a cloudly suspension or a fine white precipitate which will foul the gills of fish and create a persistent boron hazard to plants.

Detection: All borates may be tested as follows. (1) Evaporate to dryness 100 ml of sample. (2) To the residue, add methanol in the presence of concentrated sulfuric acid. Positive result: an inflammable vapor that burns with a green flame. (2,4,6).

BROMINE Br_2

Synonyms: None common.

Description: Heavy, dark reddish-brown, fuming, volatile liquid that freezes at 20°F. Vaporizes readily at room temperature. Sinks in water, gradually dissolving. Harsh, penetrating, suffocating odor. Below freezing (32°F), it combines with water to form reddish-brown crystals of hydrated bromine. Powerful oxidizing agent that reacts with organic materials, metals, and other oxidizable substances.

Toxicity:

Local - Vapor is highly irritating; liquid causes severe burns.

Systemic - Highly corrosive and toxic by inhalation and ingestion.

Aquatic - Highly toxic to all forms of aquatic life.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: There are several commercially available kits for detecting bromine as a liquid or a gas; sensitivity range is 0.01 - 300 ppm. Suppliers include Hellige, Kitagawa, Lamotte, MSA, Scott/Davis, and Taylor. (2, 5, 6).

BUTYL ACETATE

$H_3CCOOC_4H_9$

Includes: All forms of butyl: *n*, *sec*, *tert*, and *iso*.

Synonyms: Acetic acid butyl ester; butyl ethanoate.

Description: Clear, colorless, flammable, liquid. Pleasant, fruity odor. Floats; very slightly soluble. Vapor accumulates at the water's surface.

Toxicity:

Local - Vapor irritating, especially to eyes.
Systemic - Low, but high concentrations are narcotic.
Aquatic - Low to moderate.

Detection: There is no satisfactory method for detecting at water's edge. In an improvised laboratory use GC with hydrophobic column or proceed as follows. Saponify ester (about one hour) to yield ACETIC ACID and BUTYL ALCOHOL; see these entries for suitable detection methods.

BUTYL ACRYLATE $H_2C:CHCOOC_4H_9$

Synonym: Acrylic acid n-butyl ester.

Description: Colorless liquid. Sharp, fragrant odor. Floats on water, and is nearly insoluble. Combustible. Polymerizes readily upon heating unless stabilized (often with hydroquinone monomethyl).

Toxicity:

Acute - Vapor and liquid are mildly irritating.
Systemic - Low.
Aquatic - (Low).

Detection: There is no satisfactory method for detection at water's edge. As a gross presumptive test, the following method for identifying unsaturation is recommended. Separate the supernatant organic phase if possible. Add to it several drops of bromine in carbon tetrachloride (about 1% solution). Positive result: the bromine color disappears. (1, 3, 6). In an improvised laboratory, hydrolyze the ester to free the ACRYLIC ACID, then detect ACRYLIC ACID by GC or wet-chemical means.

BUTYL ALCOHOL

C_4H_9OH

Includes: All common butyl alcohols: n, sec, tert, and iso.

Synonym: Butanol.

Description: All but the tert form are colorless liquids with a pleasant, fruity odor (reminiscent of grapes); they float on water, dissolving gradually. The tert alcohol is a crystalline solid that smells like camphor; it floats on water, and dissolves.

Toxicity:

Local - Irritant vapor that can cause eye burns.
Systemic - Low.
Aquatic - Low to moderate.

Detection: Test for aliphatic alcohol as follows. Combine 2 ml of sample with 5 ml of reagent (a 10% solution of ceric ammonium nitrate in 2N nitric acid). Positive result: solution turns yellow to red. All aliphatic alcohols (prim-, sec-, and tert-) give positive result. (1, 4, 6).

BUTYLAMINE $C_4H_9NH_2$

Includes: *n*, *sec*, *tert*, and *iso* isomers.

Synonym: Aminobutane.

Description: All are colorless, volatile liquids that smell of ammonia. All but the *sec* isomer are readily miscible with water; the *sec* form dissolves gradually. All are flammable.

Toxicity:

Local - All but the *iso* form are slightly irritating; the *iso* form can cause blistering of the skin.
Systemic - Low.
Aquatic - Moderate.

Detection: There are commercial kits for detecting butylamine as a liquid or gas. One supplier is MSA; sensitivity range of MSA kit is 2-100 ppm. (1 or 2; 4 or 5; 6).

BUTYLENE GLYCOL $C_4H_{10}O_2$

Synonyms: Butanediol, dihydroxybutane.

Includes: The three common structural isomers: 1, 3; 1, 4; and 2, 3.

Description: All isomers are practically colorless and odorless, and nearly the same weight as water (they may sink or float, depending on dissolved solids in the water). The 1, 3 and 1, 4 isomers are viscous hygroscopic liquids; the 2, 3 isomer is also a heavy liquid in summer heat, but at room temperature it is crystalline; it usually floats, and readily dissolves.

Toxicity:

Human - Low.
Aquatic - Low.
Other - A major BOD problem. Look for BOD effects.

Detection: There is no suitable method for detection at water's edge. In an improvised laboratory, use GC with hydrophobic column for detection.

BUTYL MERCAPTAN C_4H_9SH

Includes the four common structural isomers: *n*, *sec*, *tert*, and *iso*.

Synonym: Butanethiol.

Description: All are colorless, mobile liquids with an overpowering, obnoxious odor like that of skunks. All float on water, and are slightly soluble. Very flammable.

Toxicity:

Human - Revolting odor may cause nausea. Narcotic in high concentrations.

Aquatic - (Low).

Other - Butyl mercaptan is one of the foulest-smelling substances known; taste and odor problems will affect the water as long as it is present.

RESPIRATOR ADVISABLE.

Detection: The offensive odor of this compound can be sensed by the unaided nose of the investigator in subtoxic concentrations. (1, 5, 6).

If desired, test for SH group as follows; all primary and secondary thiols give a positive response, and water that is rich in dissolved sulfides may also give a positive response. In a test tube, mix 1 ml of sample with 2 ml concentrated NH_4OH. Immediately cover with lead acetate paper and place the tube in a boiling-water bath. Positive result: black stain on the lead acetate paper. (1, 4, 6).

CADMIUM CHLORIDE $CdCl_2$

Synonyms: None common.

Description: Hygroscopic, white crystalline solid. Odorless. Sinks and dissolves freely.

Toxicity:

Human - High.

Aquatic - High to moderate (threshold varies from 0.1 to 72).

N. B. All soluble cadmium compounds are highly toxic to most forms of life.

Detection: The Cd and Cl components must be separately analyzed.

See AMMONIUM CHLORIDE for methods applicable to Cl.

(I). To detect Cd, mix 1 ml of sample with 1 ml of 10% NaOH and 1 ml of KCN solution. Then add 1 ml of 0.1% alcoholic di-p-nitrophenylcarbazide solution and 2 ml of 40% formaldehyde. Positive result: blue-green solution or precipitate. (2,6).

(II). A less specific test has the advantage of simplicity. Mix sample with a concentrated solution of H_2S. Positive result: bright yellow or orange precipitate. Unclear result: precipitate of any color. Negative result: no precipitate. (1,4).

(III). Cd compounds may precipitate from solution under the action of dissolved CO_2, soluble sulfides, etc. Collect surface sediment samples, boil them in aqua regia, then test the solution by method (I).

CADMIUM NITRATE

$Cd(NO_3)_2$

Synonyms: None common.

Description: White solid, amorphous or crystalline. Hygroscopic. Sinks and dissolves freely. Danger of fire and explosion in contact with organic material.

Toxicity:

Human - High.
Aquatic - High.

Detection: The Cd and NO_3 components must be separately analyzed.

See CADMIUM CHLORIDE for Cd methods.

See AMMONIUM NITRATE for NO_3 methods.

CADMIUM SULFATE $CdSO_4$

Synonyms: None common.

Description: Odorless, white, crystalline solid. Sinks and dissolves freely in water.

Toxicity:

Human - High.
Aquatic - High.

Detection: The Cd and SO_4 components must be separately analyzed.

See CADMIUM CHLORIDE for Cd methods.

See ALUMINUM SULFATE for SO_4 methods.

CALCIUM CARBIDE CaC_2

Synonyms: Acetylenogen, carbide.

Description: Grayish-black solid (lumps or crystals). Sinks in water, but is rapidly decomposed to ACETYLENE gas and lime (calcium hydroxide).

Toxicity: Low. See ACETYLENE.

Detection: ACETYLENE and lime, the reaction products of CaC_2 and water, must be separately analyzed. See ACETYLENE for suitable detection methods. Lime precipitates from solution. Collect surface sediment samples and mix them with 3M HCl to redissolve the Ca. Check water samples for high Ca values too. Ca is so prevalent and so widely distributed, Ca detection is of limited value. A gross qualitative test for Ca is given for completeness' sake; Ba and Sr interfere. Mix 1 ml of sample with 4 ml of 1% ethanolic bis(2-hydroxyanil)glyoxal. Add 1 ml of 10% NaCN and 10% NaOH solution; mix well. Add 2 ml of chloroform. Positive result: chloroform layer turns red. (1, 5, 6).

CALCIUM CYANIDE $Ca(CN)_2$

Synonyms: None common.

Description: White, crystalline solid. Decomposes in moist air and in water to HYDROCYANIC ACID, one of the most poisonous substances known. Sinks and dissolves readily in water, but is decomposed to HYDROCYANIC ACID; acidic water liberates HYDROCYANIC ACID more rapidly than neutral or basic water.

Toxicity: Highly toxic to man and aquatic life: See HYDROCYANIC ACID.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: It is the CN component that is important. See BARIUM CYANIDE for CN detection methods. See CALCIUM CARBIDE for Ca detection method and comment.

CALCIUM HYPOCHLORITE $Ca(OCl)_2$

Synonyms: Calcium oxychloride, Losantin, ingredient of Caporit, HTH, and Perchloron.

Description: White, crystalline solid. Smells like chlorine bleach. Sinks; slightly soluble in water. A strong bleaching and oxidizing agent. Hydrolyzes in water to liberate free chlorine.

Toxicity:

Local - Low; irritating and corrosive in high concentrations.

Systemic - (Low).

Aquatic - Extremely toxic to phytoplankton, especially blue-green algae. Toxicity to higher forms of aquatic life probably slight.

Other - Look for bleaching and for corrosion effects.

Detection: This hypochlorite hydrolyzes to liberate free chlorine in water; see CHLORINE for detection methods. The hypochlorite ion may also be used for detection; see HYPOCHLOROUS ACID for method.

CALCIUM PHOSPHIDE Ca_3P_2

Synonym: Photophor.

Description: Red-brown crystals or gray granular masses. Heavier than water, but decomposed by it to liberate phosphine, a spontaneously flammable and extremely toxic gas that smells of decaying fish and is slightly soluble in water.

Toxicity:

Local - Irritates the lungs and air passages.
Systemic - High, especially by inhalation.
Aquatic - Probably highly toxic to any animal in contact with the phosphine. Damage is likely to be localized, since phosphine is a slightly soluble gas.

WEAR RESPIRATOR.

Detection: Based on detection of phosphine; several commercial kits are available (reading range is 0.1 - 50 ppm). Suppliers include Kitagawa, MSA, and Scott/Davis (2, 5, 6).

CARBON DISULFIDE CS_2

Synonym: Carbon bisulfide.

Description: Clear, colorless or faintly yellow, extremely flammable liquid. Reagent grades are almost odorless, but commercial grades have a strong, disagreeable smell that is detectable in great dilution. Sinks in water; very slightly soluble. The vapors are explosive.

Toxicity:

Acute - Low.
Systemic - Moderate by inhalation; low by ingestion or skin absorption.
Aquatic - Moderate, (especially toxic to bottom life).

Detection: Commercial kits for detecting the liquid or the vapor of CS_2; sensitivity range is 5-500 ppm. Suppliers include Kitagawa, MSA, and Scott/Davis. (2,5,6).

CARBON MONOXIDE CO

Synonyms: None common.

Description: Colorless, practically tasteless and odorless gas or liquefied gas. The liquefied gas floats on water, but rapidly evaporates. Very slightly soluble in water (24 mg/liter). Flammable: Burns with violet or bright blue flame.

Toxicity:

Local - None.
Systemic - Highly toxic by inhalation.
Aquatic - High.

WEAR RESPIRATOR WHEREVER CONCENTRATIONS ABOVE A FEW ppm ARE EXPECTED.

Detection: There are several commercial kits; sensitivity range is 10-3000 ppm. Suppliers include Kitagawa, MSA, and Scott/Davis. (2,5,6).

CARBON TETRACHLORIDE CCl_4

Synonyms: Benzinoform, carbon chloride, perchloromethane, tetrachloromethane.

Description: Colorless, volatile liquid that smells like cleaning fluid. It yields vapors that are much heavier than air, and tend to collect at the water's surface. Sinks; practically insoluble. Does not burn.

Toxicity:

Local - May dry, crack, and irritate skin.
Systemic - Very slightly toxic by all routes. 1000 to 2000 ppm in air is lethal for man.
Aquatic - Probably low; especially toxic to bottom life.

Detection: There are commercial kits for both the liquid and the gas; sensitivity range is 10-300 ppm. Suppliers include Kitagawa, MSA, and Scott/Davis. (2, 5, 6).

CHLORIC ACID $HClO_3$

Synonyms: None common.

Description: Colorless solution; completely miscible with water. Very powerful oxidizing agent. Decomposes at 40°C.

Toxicity:

Local: Very irritating and corrosive.
Systemic: (Probably low). Inhalation hazard.
Aquatic: Very corrosive in high concentrations to all organic matter. Chloric acid and chlorates are widely used as herbicides and defoliants. Look for damage to plant life. Highly toxic to phytoplankton.

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE.

Detection:

(I). Use pH indicator paper or pH meter to check for strong acid. (1, 5).
(II). Test for ClO_3^- ion as follows. Add 10 ml of ice-cold 9M H_2SO_4 to 5 ml of sample. Add 0.5 ml of 5% brucine in glacial acetic acid. Positive result: solution turns blue. Periodates and nitrates interfere. (1, 5).
(III). Alternatively, test for ClO_3^- by adding 0.5 ml of saturated aqueous $MnSO_4$ and 0.5 ml of syrupy H_3PO_4 to 1 ml of sample. Heat and cool. Positive result: solution turns violet. Bromates, iodates, periodates, and nitrates interfere. (1, 5).

CHLORINE

Cl_2

Synonyms: None common.

Description: Gas or compressed, liquefied gas. Gas is greenish-yellow and much heavier than air. The liquid is clear amber. Sharp, biting odor, detectable in great dilution. Sinks in water; slightly soluble (about 1%). The water solution is acidic.

Toxicity:

Local - Powerful blistering agent and respiratory irritant; irritates skin.

Systemic - Corrodes organic matter; very harmful to lungs and respiratory passages.

Aquatic - Very corrosive in high concentrations. Highly toxic to phytoplankton, especially algae, and to fish.

Damage is likely to be especially severe to bottom life. Dilute solutions may be very toxic to plants.

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE.

Detection: There are commercial kits for detecting chlorine; sensitivity range is 0.02 - 30 ppm. Suppliers include Hach, Hellige, Kitagawa, Lamotte, Scott/Davis, and Taylor. (2,4,6).

CHLOROACETIC ACID $H_2CClCOOH$

Synonyms: Monochloroacetic acid; MCA.

Description: Deliquescent, colorless to pale brown crystalline solid. Sinks and dissolves readily.

Toxicity:

Local - Irritating and corrosive.
Systemic - Moderate.
Aquatic - (Moderate). Look for corrosion effects. This acid is a known herbicide; look for damage to plant life.

PROTECTIVE CLOTHING ADVISABLE.

Detection: Acidify samples with HCl, then follow presumptive detection method given for ACETIC ACID.

CHLOROAMINES

NH_2Cl, $NHCl_2$, NCl_3, and $AkArSO_2NNaCl$

Includes both inorganic and organic chloramines.

Synonyms: Chloramines; 2 of the most common organic chloramines are chloramines B and T.

Description. The inorganic chloramines are colorless, unstable, pungent liquids that are very soluble in water, where they slowly decompose to form nitrogen gas, HYDROCHLORIC ACID, and AMMONIUM CHLORIDE.

The organic chloramines are white to off-white crystalline solids that smell of chlorine and dissolve fairly well in water. Chloramine-B turns litmus blue, then bleaches it. The organic chloramines are used as topical antiseptics.

Toxicity:

Local - The inorganics are much more irritating than the organics.

Systemic - (Moderate).

Aquatic - The inorganics are probably highly toxic; the organics are probably moderately toxic.

Detection: There are separate detection methods for the organic and inorganic chloroamines.

Inorganic chloroamines are detected through their hydrolytic products. See HYDROCHLORIC ACID and AMMONIUM CHLORIDE for methods.

For organic chloroamines, mix the sample with concentrated H_2SO_4, dilute with water, then test for AMMONIUM CHLORIDE.

CHLOROBENZENE C_6H_5Cl

Synonyms: Chlorobenzol, phenyl chloride.

Description: Clear, colorless, mobile, volatile, flammable liquid that smells like almonds. Sinks in water; practically insoluble.

Toxicity:

Local - Liquid is slightly irritating.
Systemic - Low; high concentrations are narcotic.
Aquatic - Moderate.

Detection: There are commercial kits for detecting chlorobenzene; sensitivity range is 10-200 ppm. One supplier is MSA. Kits are available for both the liquid and the gas. (2,5,6).

CHLOROBUTADIENE

$H_2C:CHCCl:CH_2$

Synonym: Chloroprene.

Description: Colorless, flammable, and explosive liquid. Floats on water; slightly soluble.

Toxicity:

Local - Irritant to eyes, skin, mucous membranes.
Systemic - Moderate to high, especially by inhalation.
Aquatic - (Low to moderate).

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE.

Detection: Test as butadiene. Mix 2 ml of sample with 2 ml of methanol and 2 ml of 1% mercuric acetate solution. Positive result: highly colored addition compound. Butadiene interferes. (1,4,6).

Test for halogenation as follows. To 2 ml of sample add 5 ml of freshly prepared 15% NaI in acetone (DO NOT USE IF THE IODIDE SOLUTION HAS TURNED REDDISH BROWN). Positive result: a reddish-brown precipitate. If the result is unclear, put test solution in hot water (about 120°F) for 5-10 minutes; if no precipitate forms, the test is negative. All halogenated organics interfere. (1,3,6).

CHLOROFORM $CHCl_3$

Synonyms: Methyl trichloride, trichloromethane, improperly, formyl chloride or trichloride.

Description: Clear, colorless, highly refractive, volatile liquid. Characteristic sweetish odor. Burning, sweet taste. Sinks in water; slightly soluble. Decomposed by heat and light.

Toxicity:

Local - Irritating vapor and liquid.
Systemic - Low to moderate; narcotic in high concentration.
Aquatic - Moderate.

Detection: There are commercial kits for chloroform; sensitivity range is 25-600 ppm. Both liquid and vapor may be detected. Suppliers include Kitagawa, MSA, and Scott/Davis. (2, 5, 6).

CHLOROPLATINIC ACID H_2PtCl_6

Synonym: Platinic chloride.

Description: Red-brown crystals that sink and dissolve in water.

Toxicity:

Human - Moderate.
Aquatic - Moderate.

Detection: Check areas of suspected high concentration with pH indicator or meter for acidity. (1, 3).

For more specific test, mix 5 ml of sample with 10 ml of 5% aniline in 10% HCl. A precipitate forms if chloroplatinic acid is present. Collect the precipitate and add it to ethanol containing a small amount of HCl; then heat in boiling water. Positive result: the precipitate redissolves. (1, 4, 6).

CHLOROSULFONIC ACID

$ClSO_2OH$

Synonym: Sulfuric chlorohydrin.

Description: Clear to cloudy, colorless to pale yellow, fuming, very corrosive liquid. Decomposed by water to HYDROCHLORIC ACID and SULFURIC ACID.

Toxicity:

Local - Very corrosive and irritating.

Systemic and Aquatic - See HYDROCHLORIC ACID and SULFURIC ACID. Toxicity varies with pH.

Other - Look for corrosion damage.

Detection: Detect as HYDROCHLORIC ACID and SULFURIC ACID. See these entries for suggested methods.

CHLOROTHIAZIDE $C_7H_6ClN_3O_4S_2$ (two condensed rings)

Synonyms: There are many pharmaceutical synonyms for this compound, its hydrated form, and its sodium salt.

Description: White crystalline solid. The sodium salt is presumably soluble in water; the other forms are practically insoluble. These compounds are widely used as diuretics and antihypertensives.

Toxicity:

Local - Probably none.
Systemic - Low.
Aquatic - Low.

Detection: Detection may be based on any of several presumptive tests: primary amine (see PROPYLAMINE), secondary amine (see BENZYLAMINE and AMINOETHYL ETHANOL AMINE), and unsaturation (see BENZENE and ABIETIC ACID). Specific identification may be accomplished in an improvised laboratory equipped with a UV spectrophotometer.

CHLOROUS ACID $HClO_2$

Synonyms: None common.

Description: Clear, colorless, liquid, completely miscible with water. Strong oxidizing agent. Concentrated solutions are unstable, and release ClO_2.

Toxicity:

Local - High concentrations are corrosive and irritating.
Systemic - (Low).
Aquatic - Very toxic to plants and phytoplankton; low toxicity for animals.
Other - Look for corrosion damage.

Detection: Commercial detectors are available; sensitivity range is 0.1-500 ppm. Suppliers include Kitagawa, MSA, and Scott/Davis. (1 or 2, 5, 6).

CITRIC ACID $CH_2COOHC(OH)COOHCH_2COOH$

Synonyms: Hydroxypropanetricarboxylic acid, hydroxycarballylic acid.

Description: White, crystalline solid. Odorless. Strong sour taste. Sinks in water; very soluble. The common citrates (sodium, magnesium, potassium) are soluble white crystals or powders.

Toxicity:

Local - Mild irritant.
Systemic - Low.
Aquatic - Low.
Other - Increases BOD.

Detection: Mix 1 ml of sample with 1 ml of 0.01M $KMnO_4$ and 1 ml of saturated bromine water; warm slightly. Then add solid sulfosalicylic acid until the color of bromine disappears. Positive result: white precipitate. (1, 5,6).

COBALT CHLORIDE

$CoCl_2$

Synonym: Cobaltous chloride.

Description: Pale blue hygroscopic leaflets or pink to red slightly deliquescent crystals. Sinks and dissolves in water, giving a pink solution that turns blue in response to acids or heating. Aqueous solutions are acidic.

Toxicity:

Local - Low. (Used to treat anemias).
Aquatic - High.
N. B. All soluble cobalt compounds are highly or moderately toxic to a wide variety of aquatic life, including saprophytic bacteria and fish.

Detection: Cobalt can be precipitated from solution by several common natural processes; be certain to analyze surface samples of sediment. Boil the solids in aqua regia to redissolve the Co, then proceed (as below) for soluble Co.

The Co and Cl components must be analyzed separately.

See AMMONIUM CHLORIDE for methods suitable for Cl. To detect Co mix 1 ml of sample with 1 ml of reagent (made from 1 g of 1-nitroso-2-naphthol and 50 ml of glacial acetic acid in 1 liter of water). Positive result: brown stain. Ferric ion interferes. (1, 4).

COBALT NITRATE $Co(NO_3)_2$

Synonym: Cobaltous nitrate.

Description: Deliquescent, red, crystalline solid. Sinks and dissolves readily in water. Good oxidizing agent; fire risk in contact with organic material.

Toxicity:

Human - Low to moderate.
Aquatic - Moderate to high.

Detection: The Co and NO_3 components must be separately analyzed.

See COBALT CHLORIDE for Co methods.
See AMMONIUM NITRATE for NO_3 methods.

COBALT SULFATE $CoSO_4$

Synonym: Cobaltous sulfate.

Description: Red to lavender crystalline solid; deliquescent in moist air. Sinks and dissolves freely in water.

Toxicity:

Human - (Low).
Aquatic - Moderate to high.

Detection: The Co and SO_4 components must be separately analyzed.

See COBALT CHLORIDE for Co methods.
See AMMONIUM SULFATE for SO_4 methods.

COPPER CHLORIDE $CuCl_2$

Synonym: Cupric chloride.

Description: Blue-green crystalline solid. Deliquescent in moist air; efflorescent in dry air. Sinks in water; dissolves readily. The aqueous solution is acidic.

Toxicity:

Local - Irritant.
Systemic - (Low).
Aquatic - High.
N. B. All soluble copper compounds are highly toxic to a wide variety of aquatic life; even in subtoxic concentrations, it can turn shellfish green, thereby destroying their commercial value. Copper compounds characteristically give intense blue or blue-green solutions.

Detection: The Cu and Cl components must be analyzed separately.

See AMMONIUM CHLORIDE for Cl methods. Commercial kits are available for testing Cu in solution; sensitivity range is 0-3 ppm. Suppliers include Lamotte, Taylor, Hellige, and Hach. (2,5,6).

There are several simple qualitative tests.

(I). Addition of NH_4OH to dissolved copper gives a dark blue solution (2,5).

(II). Mix 1 ml of sample with 1 ml of 20% malonic acid and 1 ml of saturated rubeanic acid in methanol. Positive result: solution turns greenish black. Silver interferes. (1,5,6).

COPPER NITRATE

$Cu(NO_3)_2$

Synonym: Cupric nitrate.

Description: Deliquescent, blue, crystalline solid. Sinks and dissolves freely in water. A good oxidizing material that may combust or explode violently in contact with organic materials. Used as an insecticide in agriculture. The aqueous solution is acidic.

Toxicity:

Local - Irritant; stains skin.
Systemic - (Low).
Aquatic - High. Look for damage to fish and insect populations.
Other - May promote the growth of algae and plants.

Detection: The Cu and NO_3 components must be separately analyzed.

See COPPER CHLORIDE for Cu methods.
See AMMONIUM NITRATE for NO_3 methods.

COPPER SULFATE $CuSO_4$

Synonyms: Blue copperas, blue stone, blue vitriol, cupric sulfate.

Description: Blue crystalline solid that efflorecces in dry air. Sinks and dissolves readily in water. Nauseous metallic taste.

Toxicity:

Local - Irritant.
Systemic - Moderate by ingestion; low by skin absorption.
Aquatic - High to moderate.

Detection: The Cu and SO_4 components must be separately analyzed.

See COPPER CHLORIDE for Cu methods.
See ALUMINUM SULFATE for SO_4 methods.

CRESOL

$HOC_6H_4CH_3$

Includes: the meta, ortho, and para isomers.

Synonyms: Cresylic acid, methylphenol, hydroxytoluene.

Description: Clear liquid or crystalline solid that turns brown with age and exposure. Sinks; slightly soluble. May not sink all the way to bottom in salt water. Smells and tastes like Lysol and similar disinfectants.

Toxicity:

Local : Strongly irritant; may burn skin.
Systemic : Low to moderate; rapidly absorbed through the skin.
Aquatic : High to moderate.

WEAR PROTECTIVE CLOTHING.

Detection:

(I). A simple qualitative test for aromatic alcohols is as follows. Mix 2 ml of sample with 5 ml of reagent (a 10% solution of ceric ammonium nitrate in 2N HNO_3). Positive result: brown to greenish-brown precipitate. All low-molecular-weight aromatic alcohols test positive. (1,4).

(II). A simple qualitative test for p-cresol is as follows. Mix 2 ml of sample with 2 ml of ethanol and 2 ml of concentrated HNO_3. Add 1 ml of 0.1% alpha-nitroso-beta-naphthol in ethanol. Positive result: solution turns red. Some other phenols interfere. (1,5,6).

(III). The ortho and meta isomers can be detected by mixing the sample with 2,6-dibromoquinone in buffered solution. Positive result: solution turns red. Other phenolic compounds interfere. (1,4,6).

CROTONALDEHYDE $H_3CCH{:}CHCHO$

Synonyms: Butenal, crotonic aldehyde; methylacrolein.

Description: Clear, colorless, mobile, flammable liquid. Turns pale yellow on contact with air and light. Sharp, suffocating odor. Floats on water; slightly soluble.

Toxicity:

Local - Strong lacrimator; highly irritating to eyes, mucous membranes, and skin; both vapor and liquid are extremely irritating. Liquid can cause severe burns.

Systemic - Moderate to high by all routes, including absorption through intact skin.

Aquatic - (Moderate).

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Mix 5 ml of sample with 2 ml of 1% m-phenylenediamine hydrochloride and 1% oxalic acid in ethanol. Warm in a hot-water bath for 5 minutes. Positive result: solution turns purple. (I, 5, 6).

CYANAMIDE

$HN:C:NH$ or $N:CNH_2$

Synonyms: Hydrogen cyanamide, carbamic nitrile, cyanogenamide, carbodiimide.

Description: White, crystalline, deliquescent solid. Sinks and dissolves freely in water. Combustible. Neutral aqueous solutions are not stable, particularly if the solution comes into contact with metals.

Toxicity:

Local - Very irritating and caustic, particularly to moist skin.
Systemic - Moderate by ingestion or inhalation.
Aquatic - (Moderate).
N. B. Cyanamide toxicity does not involve the cyanide effect.

WEAR PROTECTIVE CLOTHING; RESPIRATOR ADVISABLE IN VICINITY OF RAPIDS AND FALLS.

Detection: This detection requires 2 separate steps.

(1) Test sample for HYDROCYANIC ACID (use any of the methods given at that entry). If the test for HCN is negative, proceed to step 2.
(2) Place 1 ml of sample in a test tube; add 0.1 g of zinc (preferably strips) and a few drops of 50% HCl. Test again for HCN. If step 1 is negative and step 2 is positive for HCN, the sample is presumptively positive for CYANAMIDE. Other nitriles may interfere. (1, 5, 6).

CYANOACETIC ACID $CNCH_2COOH$

Synonym: Malonic nitrile.

Description: Hygroscopic, white crystalline solid that sinks and dissolves in water.

Toxicity:

Human - High.
Aquatic - (High).

PROTECTIVE CLOTHING ADVISABLE.

Detection: There is no suitable method for use at water's edge. In an improvised laboratory, esterify the sample, extract it, then use GC for detection. (2,3,6).

CYANOBUTADIENE $N{\vdots}CCH{:}CHCH{:}CH_2$

Synonyms: Pentanedienenitrile, cyanoprene, vinylacrylonitrile.

Description: (Colorless) liquid that floats (very slightly soluble). Polymerizes into synthetic rubber.

Toxicity:

Human and aquatic - Moderate.

Detection: There is no simple specific test for this substance. As a gross presumptive test, use the method given for CHLOROBUTADIENE.

CYANOGEN BROMIDE $BrCN$

Synonym: Bromine cyanide.

Description: Colorless crystalline solid; volatile at ordinary temperatures. Sinks and dissolves in water. Aqueous solutions, especially if alkaline, are unstable.

Toxicity:

Local - Highly irritant and toxic vapors.
Systemic - Same as HYDROCYANIC ACID: High.
Aquatic - Same as HYDROCYANIC ACID: High.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Mix sample with a 10% solution of o-toluidine in pyridine. Positive result: solution turns violet or red. (1,4). Since cyanogen bromide is unstable in water, also test for the hydrolysis products; see detection methods for HYDROCYANIC ACID and bromide (see entry at ACETYL BROMIDE).

CYANOGEN CHLORIDE

$CNCl$

Synonym: Chlorine cyanide.

Description: Colorless liquid or gas (b.p. is 57°F) which sinks and dissolves in water.

Toxicity:

Local - Highly toxic and irritant vapors.
Systemic - High. See HYDROCYANIC ACID.
Aquatic - High. See HYDROCYANIC ACID.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: See CYANOGEN BROMIDE and AMMONIUM CHLORIDE.

CYCLOHEXANE C_6H_{12}

Synonyms: Hexahydrobenzene, hexamethylene, hexanaphthene.

Description: Colorless, mobile, extremely flammable liquid. Mild, sweet odor. Floats on water; practically insoluble.

Toxicity:

Human - Low.
Aquatic - Reports vary from moderate to low.

Detection: Commercial kits are available; sensitivity range is 10-600 ppm. One supplier is Kitagawa. (1,4,6).

DIAMINOETHANE $H_2N(CH_2)_2NH_2$

Synonyms: Ethylenediamine, ethanodiamine.

Description: Volatile, colorless liquid that readily absorbs CO_2 from the air. Flammable. Mild ammoniacal odor. Sinks and dissolves readily. Strongly basic.

Toxicity:

Local - Very irritating as liquid and vapor. May burn tissues.
Systemic - Moderately toxic by all routes.
Aquatic - Moderate to high.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Use gross presumptive test for primary amines. See PROPYLAMINE for recommended methods.

DIAMYLAMINE $(C_5H_{11})_2NH$

Synonym: Dipentylamine.

Description: Clear, colorless liquid. Floats, very slightly soluble.

Toxicity:

Human - (Unknown, may be moderate).
Aquatic - High to moderate.

Detection: Use either presumptive test for secondary amines, as follows.

(I). Mix 2 ml of sample with 5 ml of 0.1M benzenesulfonyl chloride in 10% aqueous NaOH. Positive result: immediate formation of a crystalline precipitate. (1, 3).

(II). Prepare reagent by dissolving 0.5 g $NiCl_2$ hexahydrate in 100 ml of water. While shaking, add CS_2 to slight excess. Just before testing sample, add 2 ml of concentrated NH_4OH to 5 ml of reagent. Then add 2 ml of sample. Positive result: a well-defined precipitate. (1, 3).

DIBUTYL PHTHALATE $(C_4H_9OOC)_2C_6H_4$

Synonyms: Butyl phthalate, DBP, phthalic acid dibutyl ester

Description: Colorless, odorless, nonvolatile, stable, oily liquid. Sinks in fresh water (but may float on salt water); very slightly soluble.

Toxicity:

Local - Somewhat irritating.
Systemic - Low.
Aquatic - High; fish are especially sensitive.

Detection: The only wet chemical test that can be easily used at water's edge is a gross presumptive test for unsaturation. Use either of the following methods.

(I). Test water samples by adding several drops of 1% potassium permanganate. Positive result: the purple permanganate solution is decolorized. (1, 5).

(II). Where there is a distinct organic phase in the sample, separate this phase and add to it several drops of bromine in carbon tetrachloride (approximately 1%). Positive result: the reddish-brown bromine solution is decolorized. (1, 5).

DICHLOROBENZENE $C_6H_4Cl_2$

Includes all three structural isomers: meta, ortho, and para.

Description: All three isomers are heavier than water and practically insoluble. Meta is a colorless liquid. Ortho is a clear, volatile, stable, heavy liquid with a pleasant, aromatic odor similar to some dry cleaning fluids. The para isomer is best known for its frequent use in mothballs and moth-flakes. It is a volatile, white, crystalline solid that sublimes without leaving a residue. Characteristic mothball odor.

Toxicity:

Local - The ortho isomer is highly irritating; otherwise, slight.
Systemic - Low.
Aquatic - Moderate; probably especially harmful to insects.

Detection: There are commercial kits for detection; sensitivity range is 10-200 ppm. Suppliers include MSA and Scott/Davis. (1 or 2,3,4).

DICHLOROETHANE (1) Cl_2HCCH_3 and (2) ClH_2CCH_2Cl

Synonyms: Formula (1) is ethylidene chloride; formula (2) is ethylene dichloride, ethylene chloride, and Dutch oil.

Description: Both forms are flammable, colorless, neutral, mobile liquids, with a characteristic sweet odor like that of ether or chloroform, and a sweet taste. Both forms sink in water, and are very slightly soluble.

Toxicity:

Local - Irritant; formula (2) is strongly irritant.
Systemic - Moderate.
Aquatic - Moderate to low.

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE.

Detection: Commercial detection kits are available; sensitivity range is 25-500 ppm. Suppliers include MSA and Scott/Davis. (1,5,6).

DICHLOROMETHANE H_2CCl_2

Synonyms: Methylene chloride, methylene dichloride.

Description: Colorless, volatile liquid that boils at 104°F. Penetrating, ethereal odor. Sinks in water; slightly soluble. Nonflammable.

Toxicity:

Local - Irritant, especially to eyes.
Systemic - Moderate to severe by all routes; ingestion most toxic route.
Aquatic - Moderate to low.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Commercial detection kits are available; sensitivity range is 25-1000 ppm. Suppliers include MSA and Scott/Davis. (1, 5, 6).

DICHLOROPHENOL $HOC_6H_3Cl_2$

N.B. There are six structural isomers, but the 2,4 isomer is apparently the most important.

Description: Combustible, white, crystalline solid. Sinks in water; slightly soluble. Acid to litmus.

Toxicity:

Local - Strong irritant.
Systemic - Moderate.
Aquatic - (Moderate to high).

WEAR PROTECTIVE CLOTHING.

Detection: Mix 2 ml of sample with 2 ml of 0.1% 4-aminoantipyrine solution and 2 ml of 0.5% sodium carbonate solution. Then add 0.5 ml of 2% potassium ferricyanide solution and stir well. Positive result: solution turns red. This test is widely used for the 2,4-dichloro isomer, but may not be valid for all other dichlorophenols. (I, 5)

DICHLOROPROPANE $ClH_2CCH_2CH_2Cl$

Synonyms: Propane dichloride.

Description: Colorless, stable, mobile, flammable liquid. Odor similar to chloroform. Sinks; very slightly soluble.

Toxicity:

Local - Irritant to eyes, skin, mucous membranes.
Systemic - Low.
Aquatic - Moderate.

Detection: Commercial detection kits are available; sensitivity is 25-500 ppm. Suppliers include MSA and Scott/Davis. (1,5,6).

DIETHANOLAMINE $(HOCH_2CH_2)_2NH$

Synonyms: Bis(hydroxyethyl)amine, DEA, diethylolamine, dihydroxydiethylamine, iminodiethanol.

Description: Deliquescent white solid which melts at 82°F; usual commercial form is viscous liquid. Sinks, but very soluble. Mild ammoniacal fishy odor. Strongly alkaline.

Toxicity:

Local - Slightly to moderately irritating to skin.
Systemic - Low.
Aquatic - Reports vary widely, from low to moderate.
Other - Raises BOD.

Detection: First, follow method for detecting MONOETHANOLAMINE. If test is positive and further resolution is required, test for secondary amine (see DIAMYLAMINE) to distinguish from MONOETHANOLAMINE.

DIETHYLAMINE $(C_2H_5)_2NH$

Synonyms: None common.

Description: Flammable, strongly alkaline, colorless liquid. Ammoniacal odor. Floats; very miscible with water. The hydrochloride is also known; it is a hygroscopic liquid, slightly heavier than pure water and soluble in it; its reaction is presumably neutral to slightly acid.

Toxicity:

Local - Irritating to eyes, mucous membranes, and skin; especially irritating by inhalation.
Systemic - (Low to moderate).
Aquatic - Moderate.

Detection: Commercial detection kits are available; sensitivity is 5-200 ppm. Suppliers include MSA. (1,5,6).

DIETHYLENE GLYCOL $(HOCH_2CH_2)_2O$

Synonyms: DEG, dihydroxydiethyl ether, oxydiethanol.

Description: Clear, colorless, practically odorless, syrupy liquid; non-corrosive and very hygroscopic.

Toxicity:

Human and aquatic - Practically nontoxic.
Other: Raises BOD.

Detection: There is no simple detection method that can be used at water's edge. Instrumental techniques of analysis (such as GC and IR) are required.

DIETHYL PHTHALATE $(C_2H_5OOC)_2C_6H_4$

Synonyms: DEP, ethyl phthalate.

Description: Clear, stable, colorless liquid; bitter taste.
Toxic; insoluble. Combustible.

Toxicity:
Local - Strong irritant to eyes and mucous membranes.
Systemic - Moderate by ingestion and inhalation.
Narcotic in high concentrations.
Aquatic - High; fish are especially sensitive.

WEAR PROTECTIVE CLOTHING. PROTECT EYES.

Detection: Use the same methods given for DIBUTYL PHTHALATE.
If more specific identification is required and an equipped
laboratory is available, use UV spectrometry.

DIISOPROPANOLAMINE $(CH_3CHOHCH_2)_2NH$

Synonym: DIPA.

Description: White crystalline solid; ammoniacal fishy odor. Floats and dissolves. The article of commerce is usually a clear, colorless liquid.

Toxicity:

Local - Irritant; may cause skin burns.
Systemic - Moderate to low.
Aquatic - Moderate.

Detection: Use presumptive test given for MONOETHANOLAMINE (see that entry). If further resolution is required, test for a secondary amine (see the methods given in the DIAMYLAMINE entry) to distinguish this compound from MONOETHANOLAMINE.

DIISOPROPYLAMINE $((CH_3)_2CH)_2NH$

Description: Colorless, volatile, flammable liquid; amine odor. Floats; slightly soluble.

Toxicity:
Local - Strong irritant.
Systemic - Moderate.
Aquatic - Moderate.

WEAR RESPIRATOR;PROTECTIVE CLOTHING ADVISABLE

Detection: Test for a secondary amine (see DIAMYLAMINE for methods).

DIMETHYLAMINE $(CH_3)_2NH$

Synonym: DMA.

Description: Colorless gas at ordinary temperatures. Liquefies at 45°F. Very flammable. Strong ammoniacal odor; detectable at a few ppm. Rather soluble in water, giving a strongly alkaline solution. DMA is commercially available as a compressed gas and as aqueous solution (about 40%). Liquid is clear and colorless; gas is heavier than air.

Toxicity:

Local: Both gas and liquid forms are irritant. [illegible]

Systemic: Low.

Aquatic: Moderate.

Detection: Colorimetric kits are available, sensitivity to 1-250 ppm. Suppliers include MSA. [illegible]

[illegible]

[illegible]

Description: Colorless, [illegible] liquid which has been used as a war gas. [illegible]

[illegible]

[illegible]

[illegible]

DIMETHYL SULFOXIDE $(CH_3)_2SO$

Synonyms: DMSO, methyl sulfoxide.

Description: Colorless, nearly odorless, hygroscopic liquid. Slightly bitter taste. Combustible. A powerful solvent that penetrates the skin and other tissues, often causing burns.

Toxicity:

Local - Irritates skin; may cause redness and wheals.
Systemic - Low.
Aquatic - (Low to moderate). High concentrations may be very damaging to plants as well as animals.

Detection: Commercial kits are available; sensitivity is 25-250 ppm. Suppliers include MSA. (2, 5, 6).

DINITROBENZENE $C_6H_4(NO_2)_2$

Synonym: Dinitrobenzol.

Description: White or yellowish crystals that sink in water; very slightly soluble.

Toxicity:

Local - Strong irritant.
Systemic - Moderate to high by inhalation and ingestion; rapidly absorbed through the skin.
Aquatic - High.

WEAR PROTECTIVE CLOTHING, RESPIRATOR ADVISABLE.

Detection: Extract 50 ml of sample with 5 ml of ether. Let the ether evaporate (WITHOUT HEATING) in open air, until almost dry. Add 1 ml of acetone and 1 ml of dilute alcoholic NaOH. Positive result: reddish turns greenish yellow. Dinitrochlorobenzene, dinitronaphthalene, dinitrotoluene, and dinitroaniline interfere. (2,1)

DINITROPHENOL $(NO_2)_2C_6H_3OH$

Synonyms: Aldifen, hydroxydinitrobenzene.

Description: Yellowish to yellow crystals, which sublime. Only slightly soluble in cold water, soluble in hot water. Soluble in alkaline solutions. The sodium salt of dinitrophenol is readily soluble in water. Frequently used as a colorimetric pH indicator; it is colorless in strong acid solution, but turns brilliant yellow in dilute acid solutions.

Toxicity:

Human: Highly toxic by all routes, including absorption through the intact skin.
Aquatic: High.

WEAR PROTECTIVE CLOTHING/RESPIRATOR IF AVAILABLE.

Detection: Mix 2 ml of sample with 2 ml of 0.1N stannous chloride in 1N HCl solution. Positive result: yellow for the 2,4 isomer, violet-blue for the 2,5 and 2,6 isomers. (D.S.P.).

TRIMETHYLPHOSPHITE $(CH_3O)_3P$

Synonyms: Trimethoxyphosphine.

Description: Colorless, very volatile, flammable liquid. Sharp odor of garlic. Water, practically insoluble.

Toxicity:

Local - Very irritating; cannot be tolerated in high concentration.
Systemic - Moderate to high, cumulative.
Aquatic - Moderate to high, especially to surface life.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Mix 1 ml of sample with 10 ml of 10% NaOH solution containing a few drops of phenolphthalein indicator. Heat in a water bath for 5 minutes. Positive result: solution turns pink to red. Neutralize sample before beginning test. (E,T,V).

ETHYL ACRYLATE

$CH_2{:}CHCOOC_2H_5$

Synonyms: None

Description: Clear, colorless, very flammable liquid. Floats; nearly insoluble. Sharp, fragrant odor. Readily polymerized; HYDROQUINONE is frequently added to inhibit polymerization. The polymer is a clear plastic, the common polyacrylate and polyacrylic resin of commerce.

Toxicity:

Local - A potent lacrimator, very irritating to eyes and skin.
Systemic - Moderate.
Aquatic - Moderate to low.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: There is no adequately specific test for use at water's edge. In an improvised laboratory, hydrolyze the ester, then follow detection methods for ACRYLIC ACID (see that entry). As a gross presumptive test, test for unsaturation as follows:

(i) When the acrylate forms a distinct organic phase, separate that phase and add to it a few drops of bromine in carbon tetrachloride (approximately 1%). Positive result: the reddish-brown bromine color disappears. (1, 3).

(ii) When there is no distinct organic phase, add a few drops of aqueous potassium permanganate solution (about 1%). Positive result: the purple permanganate color disappears. (1, 3).

ETHYL ALCOHOL C_2H_5OH

Synonyms: Cologne spirits, ethanol, ethyl hydroxide, ethylic alcohol, fermentation alcohol, grain alcohol, Lavacol, methyl carbinol, neutral spirits, proof spirits, spirit of wine.

Description: Clear, colorless liquid. Completely miscible with water. Flammable even when mixed with some water. The pure substance has well known taste and odor, but industrial and antiseptic grades are denatured with a variety of unpleasant substances which greatly alter the taste, odor, and toxicity.

Toxicity:

Local - None.
Systemic - Drunkenness by ingestion; denatured grades are toxic by ingestion.
Aquatic - Low to moderate, depending on the denaturants and their concentration. Various salts of MERCURY are frequently used as denaturants; they are bio-accumulative poisons.

Detection: Several commercial kits are available for detection, sensitivity is 200-5000 ppm. Suppliers include Kitagawa, MSA, and Scott-Davis. (2,7,8).

ETHYLAMINE $CH_3CH_2NH_2$

Synonyms: Aminoethane, monoethylamine.

Description: Colorless, flammable, volatile liquid which vaporizes at 62°F. Ammoniacal odor. Floats, but dissolves quickly, forming a strongly alkaline solution.

Toxicity:

Local - Very irritating to eyes, mucous membranes, and skin.
Systemic - Moderate by ingestion.
Aquatic - Moderate.

PROTECT EYES FROM VAPOR AND LIQUID; RESPIRATOR ADVISABLE.

Detection: Commercial kits are available for detection; sensitivity range is 20-200 ppm. Suppliers include MSA, D, S, N.

ETHYL BENZENE $C_6H_5C_2H_5$

Synonyms: Ethyl benzol, phenylethane.

Description: Colorless flammable liquid that smells like benzene. Flash point at 85°F. Floats; slightly soluble.

Toxicity:
Local - Vapor and liquid are slightly irritating.
Systemic - Low.
Aquatic - Moderate.

Detection: If an improvised laboratory is available, use UV spectrometry for the identification. Ethyl benzene has distinctive absorption between 290 and 247 millimicrons. As a gross presumptive test, test for unsaturation (see ETHYL ACRYLATE for recommended methods).

ETHYLENE $CH_2{:}CH_2$

Synonyms: Bicarburetted hydrogen, elayl, ethene, etherin, heavy carburetted hydrogen, olefiant gas.

Description: Colorless gas or liquefied gas under pressure. Very weak, sweetish odor. Vaporizes very quickly. Very flammable. Floats; slightly soluble.

Toxicity:

Human - Virtually nontoxic.

Aquatic - Moderate to high; some fish are very sensitive.

Detection: Commercial detection kits are available, sensitivity range is 0.5-100 ppm. Suppliers include Kitagawa, MSA, and Scott/Davis. (1, 4, 6).

ETHYLENE CYANOHYDRIN HOC_2H_4CN

Synonyms: Glycol cyanohydrin, hydracrylonitrile, hydroxypropionitrile.

Description: Colorless to straw-colored liquid. Sinks, but completely miscible.

Toxicity:

Local - None.
Systemic - Low.
Aquatic - Low.

Detection: See ACETONE CYANOHYDRIN for recommended method. The method given there applies without change to this compound.

ETHYLENEDIAMINETETRAACETIC ACID $(HOOCCH_2)_4NC_2H_4N$

Synonyms: EDTA, ethylenebisiminodiacetic acid, ethylenedinitrilotetraacetic acid.

Description: Colorless crystals; sink and slowly dissolve in water. A powerful chelating agent. Several common metallic salts are called "edetates"; they are very soluble in water. EDTA and the edetates are widely used in detergents, agriculture, industry, and medicine.

Toxicity:

Human - Low.
Aquatic - Moderate.

Detection: Commercial detection kits are available; suppliers include Hach and Lamotte. (2,5,6). There is also a simple and sensitive wet-chemical test. Add 5 ml of 0.05M cobaltous nitrate solution to 5 ml of sample. Mix and then add a few drops of 0.05M ferric chloride solution. Positive result: solution turns red. (2,4,6).

ETHYLENE GLYCOL $HO(CH_2)_2OH$

Synonyms: Ethanediol, ethylene alcohol, dihydroxyethane.

Description: Clear, colorless, hygroscopic, flammable liquid. Sweet taste and weak, sweet odor (like antifreeze). Sinks and dissolves readily. A common antifreeze.

Toxicity:

Local - None
Systemic - Low.
Aquatic - Low.
Other - Raises BOD; this is the major problem.

Detection: The recommended detection method requires an ice bucket for cooling. Mix 5 ml of sample with 2.5 ml of 6.6% sodium periodate solution. Cool to 32°F, then add 1 ml of saturated potassium nitrate solution. Add 2 ml of 1% aqueous phenylhydrazine hydrochloride and 1 ml of 2% potassium ferricyanide. Cool again to 32°F, then add 5 ml of chilled concentrated HCl. Positive result: solution turns red. Sorbitol interferes. (1,5,6).

ETHYLENE GLYCOL DIACETATE $CH_3COOCH_2CH_2OOCCH_3$

Synonym: Glycol diacetate.

Description: Colorless liquid. Faint odor. Burns. Widely used solvent. Sinks and dissolves.

Toxicity:

Human - Low.
Aquatic - Low.
Other - Raises BOD.

Detection: There is no suitable method for detection at water's edge. In an improvised laboratory, use GC.

ETHYLENE GLYCOL MONOBUTYL ETHER $OH(CH_2)_2OC_4H_9$

Synonyms: Butoxyethanol, butyl cellosolve.

Description: Colorless liquid with a mild odor. Floats and dissolves. In general, an inert solvent for both water and organics.

Toxicity:

Human - Low.
Aquatic - Low.

Detection: There is no suitable method for detection at water's edge. In an improvised laboratory, use GC.

ETHYLENEIMINE

$H_2\overline{CNHC}H_2$

Synonyms: Azacyclopropane, aziridine, dimethyleneimine.

Description: Clear, colorless liquid. Strong, fishy amine odor. Floats and dissolves readily. Very strongly alkaline and corrosive. Caution: extremely flammable, and polymerizes with explosive effect. An inhibitor (presumably HYDROQUINONE) is often added to control spontaneous polymerization.

Toxicity:

Local - Vapor extremely irritating; liquid causes severe burns.
Systemic - High by all routes, including skin absorption.
Aquatic - Moderate.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Commercial kits are available; sensitivity range is 2-100 ppm. One supplier is MSA. (1, 5, 6).

FERRIC CHLORIDE $FeCl_3$

Synonyms: Ferric perchloride, ferric trichloride, flores martis, iron chloride, iron perchloride, iron trichloride.

Description: The anhydrous solid is blackish brown; the crystalline form is orange-yellow and very deliquescent. Sinks and dissolves, but decomposes spontaneously to yield HYDROCHLORIC ACID and FERRIC HYDROXIDE when exposed to moist air and light.

Toxicity:

Human - Low.
Aquatic - Highly variable, from High to Low.

Detection: The Fe and Cl components must be separately analyzed.

See FERRIC HYDROXIDE for Fe methods.
See AMMONIUM CHLORIDE for Cl methods.

FERRIC HYDROXIDE $Fe(OH)_3$

Synonyms: Ferric hydrate, iron hydroxide, iron hydrate, iron oxide (hydrated), ferric oxide (hydrated).

Description: Brown to reddish brown solid, often as a flocculant precipitate. Sinks; almost insoluble.

Toxicity:

Human - Low.
Aquatic - Moderate to high.

Detection: Prepare suspect solids for testing by dissolving in 3M HCl. Then proceed as follows.

(I). Mix the sample with 1% ammonium thiocyanate solution. Positive result: solution turns intensely red.

(II). Mix the sample with 1% potassium ferrocyanide solution. Positive result: deep blue solution or precipitate. Since many waters and bottom solids are high in iron, background may be very high. (2, 5, 6).

Several commercial kits are available for detecting dissolved iron; suppliers include Lamotte, Taylor, Hellige, and Hach. (2, 5, 6).

FERRIC SULFATE $Fe_2(SO_4)_3$

Synonyms: Ferric sesquisulfate, ferric trisulfate, iron persulfate, iron sulfate, iron tersulfate.

Description: The anhydrous form is a grayish white powder; the crystalline form is yellow. Both forms sink, but the crystals are very soluble, while the anhydrous form is slightly soluble.

Toxicity:

Human - Low.
Aquatic - Moderate to high.

Detection: The Fe and SO_4 components must be separately analyzed.

See FERRIC HYDROXIDE for Fe methods.
See ALUMINUM SULFATE for SO_4 methods.

FERROUS HYDROXIDE $Fe(OH)_2$

Synonym: Iron hydroxide.

Description: White crystals, which may have a tinge of green. Sinks; almost insoluble. Spontaneously converted to FERRIC HYDROXIDE on exposure to air, but the conversion is slow unless the material is very finely divided.

Toxicity:

Human - Low.
Aquatic - Highly variable, from High to Low.

Detection: Since this compound spontaneously becomes FERRIC HYDROXIDE on exposure to air, test for ferric iron by the methods given in the FERRIC HYDROXIDE entry. Ferric iron is reconverted to ferrous iron when it is mixed with 3M H_2SO_4. Test for ferrous iron by either of the following methods.

(I). Mix the sample with 0.5% potassium ferricyanide. Positive result: deep blue solution or precipitate. (2, 5, 6).

(II). Mix the sample with a 2% alcoholic 2, 2'-dipyridyl (or 1, 1--phenanthroline) solution. Positive result: solution turns red or pink. (2, 5, 6).

FERROUS SULFATE $FeSO_4$

Synonyms: Copperas, green vitriol, iron sulfate, iron vitriol, sal chalybdis.

Description: Industrial grades are greenish or yellow-brown hygroscopic crystals or granules. Pure grades are white, yellow, or blue-green, depending on hydration. Odorless. Sinks; slightly soluble. Salty taste. Slowly oxidized to FERRIC SULFATE in air.

Toxicity:

Human - Low.
Aquatic - Highly variable, from High to Low.

Detection: Ferrous iron is converted to ferric iron in air. Test for both ferrous and ferric forms. The iron and sulfate components must be analyzed separately.

See FERROUS HYDROXIDE for ferrous methods.
See FERRIC HYDROXIDE for ferric methods.
See ALUMINUM SULFATE for SO_4 methods.

FERROUS SULFITE $FeSO_3$

Synonyms: None common.

Description: White or greenish crystals. Sinks and dissolves. Slowly oxidized to the corresponding ferric salt.

Toxicity:

Human - Low.
Aquatic - Moderate.

Detection: The ferrous and sulfite components must be separately analyzed.

See FERROUS HYDROXIDE for ferrous methods.

Detect sulfite as follows. Mix 1 ml saturated $Zn(NO_3)_2$ with 1 ml of 1N $K_4Fe(CN)_6$ solution. Add to this 1 ml of 1% sodium nitroprusside solution; a white precipitate will form. Then add 1 ml of the sample. Positive result: the white precipitate turns red. (1, 5, 6).

There are several commercial detection kits for sulfites; suppliers include Lamotte, Taylor, Hellige, and Hach. (1, 4, 6). Sensitivity range is 2-300 ppm.

FLUORINE F_2

Synonyms: None common.

Description: Pale, greenish-yellow gas, usually sold commercially as an extremely cold (-306°F) liquefied gas, which is clear to yellow. Strongly acid to litmus. Highly reactive at room temperature. Reacts with water to form HYDROFLUORIC ACID, HYDROGEN PEROXIDE, ozone, oxygen, and oxides of fluorine.

Toxicity:

Local - Extremely irritating to eyes, lungs, and skin. Liquid causes severe skin and eye burns.
Systemic - High.
Aquatic - High.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: See HYDROFLUORIC ACID and HYDROGEN PEROXIDE for the detection methods applicable to FLUORINE'S reaction products with water.

FORMALDEHYDE HCHO

Synonyms: Formalin, formic aldehyde, formol, methanal, oxymethylene.

Description: Colorless, very flammable gas, with a suffocating, biting odor. The gas is readily water soluble, and is usually sold as a 37-50% solution. The aqueous solution is not flammable, but it releases flammable gas. Because formaldehyde polymerizes, it is often mixed with METHANOL (about 15%) to inhibit polymerization.

Toxicity:

Local - Gas very irritating. Liquid causes burns.
Systemic - Moderate.
Aquatic - Moderate.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Commercial kits are available; sensitivity range is 1-100 ppm. Suppliers include MSA and Scott/Davis. (1, 5, 6).

FORMIC ACID $HCOOH$

Synonyms: Hydrogen carboxylic acid, methanoic acid.

Description: Colorless, fuming acid. Sharp, biting odor. A strong acid, dangerously caustic. Acid to litmus. Sinks; completely miscible. Combustible.

Toxicity:

Local - Irritant vapor; liquid causes burns.
Systemic - Moderate.
Aquatic - Moderate; not toxic to fish except insofar as it affects pH and osmotic pressure.
Other - Look for corrosion effects.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: The recommended method requires an ice bucket (or equivalent) for cooling. Mix 2 ml of sample with 0.1 g of magnesium ribbon. Immerse in an ice bath, then add dropwise, at one-minute intervals, 10 drops of concentrated HCl. Finally, add 2 ml of 0.3% chromotropic acid in 12M sulfuric acid. Positive result: a white precipitate forms, and the solution turns green or yellow. (1, 5, 6).

FRUCTOSE $C_6H_{12}O_6$

Synonyms: Fruit sugar, levulose.

Description: White crystals or powder. Sinks and dissolves. The sweetest of the common sugars. Combustible.

Toxicity:

Human and aquatic - Practically nontoxic.
Other - Raises BOD.

Detection: Test the sample by the following methods. Each method is presumptive, but taken together they build up a fairly conclusive case for the presence of fructose.

(I). Mix 2 ml of sample with 2 ml of 0.1% ethanolic resorcinol and 6 ml of concentrated HCl containing 0.75 mg of ferric chloride per 100 ml. Heat in a water bath. Positive result: solution turns cherry red. (1,5,6).

(II). Mix 1 ml of sample with 10 ml of 4% ammonium molybdate. Add 0.25 ml of 1:3 nitric acid and heat at 150°F for 3 minutes. Positive result: solution turns blue. (1,5,6).

(III). Mix 1 ml of sample with 0.4 ml of 0.2% aqueous orcein solution and 1 ml of 85% phosphoric acid. Heat in boiling water for 10 minutes. Positive result: solution turns yellow and/or a yellow precipitate forms. (1,5,6).

FUMARIC ACID

HOOCCH:CHCOOH

Synonyms: Allomaleic acid, boletic acid, trans-butenedioic acid, trans-ethylenedicarboxylic acid, lichenic acid.

Description: Colorless, odorless crystals or leaflets. Sinks; practically insoluble in cold water, but moderately soluble in hot water. Tastes like fruit acid.

Toxicity:

Local - Irritates eyes and skin.
Systemic - Low.
Aquatic - Low.
Other - May increase BOD.

Detection: There is no adequately specific test for use at water's edge. Use the following gross presumptive test for unsaturation. To 2 ml of sample add several drops of 1% aqueous $KMnO_4$. Positive result: the purple permanganate solution is decolorized. (1, 3, 6).

FURFURAL

$\overline{\mathrm{OCH:CHCH:}}\mathrm{CCHO}$

Synonyms: **Artificial oil of ants, furaldehyde, pyromucic aldehyde.**

Description: Colorless, mobile, oily liquid when pure; turns yellow to reddish brown on exposure to light and air. Penetrating odor like almond oil. Slowly resinifies on exposure to the elements. Combustible.

Toxicity:

Local - Irritant vapor.
Systemic - Moderate.
Aquatic - Moderate.

Detection: Mix 2 ml of sample with 2 ml of 0.5% oxalic acid containing 1% of disodium phosphate. Then add 3 ml of 10% aniline in glacial acetic acid. Positive result: solution turns red. (1, 5, 6).

FURFURYL ALCOHOL $\overline{\text{OCH:CHCH:C}}\text{CH}_2\text{OH}$

Synonyms: Furanecarbinol, furfuralcohol, furyl carbinol, hydroxymethylfuran.

Description: Colorless, mobile liquid; becomes dark red or brown on exposure to light and air. Sinks; very soluble in water, but decomposes. Solutions of furfuryl alcohol that have been exposed to air and light, or those that have been standing for some time, are almost insoluble in water.

Toxicity:

Local - Slightly irritating liquid and vapor.
Systemic - Moderate to low.
Aquatic - Moderate.

Detection: Commercial kits are available for detection; sensitivity range is 25-500 ppm. MSA is one supplier. (2,5,6).

GALLIC ACID $(OH)_3C_6H_2COOH$

Synonym: Trihydroxybenzoic acid.

Description: Colorless or slightly yellow crystals. Sinks; sparingly soluble.

Toxicity:

Human - Low.
Aquatic - Moderate.

Detection: Add dilute ferric chloride to the sample. Positive result: dark blue solution and precipitate. (1, 5, possibly 6).

GLUCONIC ACID

$CH_2OH(CHOH)_4COOH$

Synonyms: Glycogenic acid, glyconic acid.

Description: Light brown syrup with mildly acid taste. Faint odor of vinegar. Sinks and dissolves.

Toxicity:

Human and Aquatic - Practically nontoxic.
Other - Raises BOD.

Detection: There is no suitable method for detection at water's edge. In an improvised laboratory, the acid may be esterified and the ester identified by GC.

GLUCOSE $C_6H_{12}O_6$

Synonyms: Corn sugar, corn syrup, dextrose, grape sugar, starch syrup.

Description: The pure substance is a white crystal, but commercial forms include syrups that vary from clear and colorless to dark brown and opaque. Sinks and dissolves.

Toxicity:

Human and Aquatic - Practically nontoxic.
Other - Raises BOD.

Detection: Use any of the following presumptive tests. Many other sugars will test positive, but these tests are sufficient for damage assessment.

(I). Mix 1 ml of sample with 2 ml of 0.18% potassium ferricyanide and 2% sodium carbonate. Positive result: solution turns blue. (1,5,6).

(II). Mix 1 ml of sample with 2 ml of 0.27% KH_2PO_4 and 4 ml of 7.5% ammonium molybdate. Positive result: solution turns blue. (1,5,6).

(III). Mix 5 ml of sample with 5 ml of 5% KOH and 2 ml of 1% sodium biselenite. Positive result: a colloidal precipitate. (1,5,6).

GLYCEROL

$H_2COHCHOHCH_2OH$

Synonyms: Glycerine, glycyl alcohol, propanetriol.

Description: Clear, colorless to pale yellow, odorless syrup.
Sweet, warm taste. Hygroscopic. Sinks; miscible.

Toxicity:

Human and Aquatic - Practically nontoxic.
Other - Raises BOD.

Detection: Each of the following methods is a presumptive test for glycerol. Taken together, they build up a fairly conclusive case for the presence of glycerol.

(I). Mix 1 ml of sample with 3 ml of 1:1 H_2SO_4. Add a few drops of 7.5% potassium bichromate solution. Positive result: decolorization of the orange bichromate solution. (1, 4, 6).

(II). Mix 4 ml of sample with 1 ml of 5% codeine in ethanol. Add 5 ml of 1:3 H_2SO_4. Heat for 2 minutes in boiling water. Positive result: solution turns blue. (1, 4, 6).

(III). Mix 1 ml of sample with 1 ml of freshly prepared 10% catechol solution and 4 ml of 3:1 H_2SO_4. Heat in boiling water for 15 minutes. Positive result: solution turns red. (1, 4, 6).

HEPTANOL

$C_7H_{15}OH$

Synonyms: Heptyl alcohol, hydroxyheptane, enanthyl alcohol, methyl amyl carbinol.

Description: There are 3 important isomers. All are colorless, fragrant liquids that float and are slightly soluble. May cause flowing water to froth. All are flammable.

Toxicity:

Human - Low to moderate, depending on isomer.
Aquatic - (Moderate).

Detection: Use gross presumptive test for aliphatic alcohols. See BUTYL ALCOHOL for recommended methods.

HEXAMETHYLENE DIAMINE $H_2N(CH_2)_6NH_2$

Synonyms: Diaminohexane, hexane diamine.

Description: Colorless leaflets that are very soluble in water.

Toxicity:

- Local - Strong irritant.
- Systemic - Moderate by ingestion.
- Aquatic - Moderate.

PROTECTIVE CLOTHING ADVISABLE.

Detection: Use gross presumptive test for primary amines.
See PROPYLAMINE for recommended methods.

HEXANOL

$C_6H_{13}OH$

Synonyms: Amyl carbinol, hexyl alcohol.

Description: Only the _n_ isomer is common. Colorless liquid. Floats; slightly soluble. Combustible.

Toxicity:

Human - Low.
Aquatic - Moderate.

Detection: Use gross presumptive test for aliphatic alcohols. See BUTYL ALCOHOL for recommended methods.

HYDRAZINE H_2NNH_2

Synonym: Diamine.

Description: Colorless, fuming, hygroscopic, extremely flammable liquid. Strong odor. Miscible with water; may sink or float depending on water; sinks in clean fresh water. Weakly basic.

Toxicity:

Local - Vapor and liquid are strong irritants that may cause burns.
Systemic - Moderate. May be absorbed through intact skin.
Aquatic - High.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Commercial test kits are available; sensitivity range is 0.0-0.5 ppm. Suppliers include Hach, Hellige, and Lamotte. (2, 5, 6).

If test kit is not available, mix 1 ml of sample successively with: (1) 1 ml of 1% aqueous pyridylpyridinium chloride, (2) 1 ml of 1N NaOH, and (3) 1 ml of concentrated HCl. Positive result: solution turns red. (1, 5).

HYDROCHLORIC ACID HCl

Synonyms: Hydrogen chloride, muriatic acid.

Description: Clear, colorless to slightly yellow, fuming, acrid liquid. Cannot catch fire. Strongly corrosive: a powerful acid that is easily detected by litmus and other indicators. Miscible with water.

Toxicity:

Local - Extremely irritating vapor, liquid causes burns.
Systemic - Moderate.
Aquatic - Moderate.
Other - Look for corrosion effects.

Detection: Commercial kits are available; sensitivity range is 2-1,000 ppm. Suppliers include Hach, Hellige, Lamotte, MSA, and Scott/Davis. (1,5,6).

Because this is one of the strongest acids known, pH papers and pH meters may be used to monitor the spill. In strongly alkaline waters, use the test for the chloride ion to detect dilute solutions; see AMMONIUM CHLORIDE for recommended method.

HYDROCYANIC ACID

HCN

Synonyms: Formonitrile, hydrogen cyanide, prussic acid.

Description: Colorless liquid that vaporizes at 79°F. Very soluble. The gas is lighter than air and the liquid is lighter than water, but is miscible. Very weakly acid; doesn't redden litmus. The rising vapor is very toxic and explosive. Widely used in rodenticides and insecticides. Characteristic odor of bitter almonds, which is detectable at a few parts per million. Intensely poisonous.

Toxicity:

Human - High.
Aquatic - High. Toxic to fish and plankton.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Commercial kits are available for detection; sensitivity range is 2-3000 ppm. Suppliers include Kitagawa, MSA, Hach, and Scott/Davis. (1, 5, 6).

HYDROFLUORIC ACID

HF

Synonyms: None common.

Description: Clear, colorless to slightly tinted, fuming, mobile liquid. Sharp odor. Will attack glass, rock, sand, or any other material that contains silica. Completely miscible with water. Cannot catch fire.

Toxicity:

Local Extremely irritant to eyes, skin, lungs.
Systemic - High. Toxic by skin penetration.
Aquatic - High to moderate.
Other - Look for corrosion effects in rocks, sand, and other silica-bearing materials.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: For gross detection of acidity, use pH papers or pH meter. For more specific detection, use any of the commercially available kits; sensitivity range is 0.2-7.5 ppm. Suppliers include Hellige, Lamotte, MSA, and Scott/Davis. (1,5,6).

HYDROGEN PEROXIDE $HOOH$

Synonyms: **Albone, Hydrogen dioxide, peroxide, superoxol.**

Description: Colorless, heavy liquid, usually sold in aqueous solution (various strengths). Very unstable; breaks down readily into water and oxygen. Commercial solutions often contain a decomposition inhibitor, e.g. acetophenidin or acetanilide. Bitter taste. A strong oxidizing agent.

Toxicity:

Local - Strong solutions (35% and higher) are irritant.
Systemic - Moderate.
Aquatic - Moderate.
Other - Look for bleaching and strong evidence of oxidation.

Detection: Mix sample with 1N HCl, then add several drops of 1% $KMnO_4$. Positive result: the purple permanganate solution is bleached. (1, 3, 6).

HYDROQUINONE $C_6H_4(OH)_2$

Synonyms: **Benzenediol, hydroquinol, paradihydroxybenzene, quinol, Tecquinol.**

Description: **Combustible white crystals that sink and dissolve. Unstable in the presence of air and light. Aqueous solutions turn brown in air.**

Toxicity:

Local - **Irritant; can sensitize skin.**
Systemic - **Moderate.**
Aquatic - **Moderate to high.**

Detection: **Extract 10 ml of sample with 5 ml of ether, then separate the ether layer. Mix the ether layer with 5 ml of 1:1 HNO_3. Let it stand for 5 minutes, then dilute with 10 ml of water. Carefully make basic (alkalify) with 10% NaOH. Positive result: solution turns violet.** (1, 5).

HYDROXYLAMINE NH_2OH

Synonyms: Oxammonium.

Description: Unstable white flakes or crystals that sink and dissolve. Very hygroscopic. Rapidly decomposes at room temperature, especially in the presence of oxygen and carbon dioxide. Alkaline reaction. The acid sulfate, hydrochloride, and sulfate are common derivatives.

Toxicity:

Local - Irritant.
Systemic - Moderate. A KNOWN CARCINOGEN.
Aquatic - Moderate.

Detection: Mix 2 ml of sample with 2 ml of 1N HCl. Add to it 0.1 g of alloxan and 0.1 g of sodium carbonate. Positive result: solution turns violet. (1, 5, possibly 6).

HYPOCHLOROUS ACID **HOCl**

Synonyms: None common.

Description: Greenish-yellow aqueous solution. Highly unstable, weak acid; pH not a reliable indicator. Decomposes to HYDROCHLORIC ACID and oxygen. Can exist only in dilute solution. Very corrosive.

Toxicity:

Local - Irritant.

Systemic - Moderate.

Aquatic - Moderate for fish and animal life; highly toxic to plants and algae.

Other - Look for corrosion and bleaching effects.

Detection: Test for the hypochlorite ion as follows. Prepare 2 samples in separate test tubes. To 1 tube add a 0.1% solution of indigo, drop by drop. To the other tube add 0.01N $KMnO_4$ solution, drop by drop. Positive result: the indigo solution is decolorized, but the permanganate solution is not. (1, 5, 6 -- animals only).

Also refer to tests for HYDROCHLORIC ACID and the chloride ion (see AMMONIUM CHLORIDE).

INDOLE $\overline{(CH)_4CC}\underline{(CH)_2NH}$

Synonyms: Benzopyrrole.

Description: White to yellowish scales which turn red on exposure to air and light. In high concentration, the odor is unpleasant and fecal; in dilution, the odor is pleasant. Sinks; slightly soluble.

Toxicity:

Human - Carcinogenic. Other effects probably low.
Aquatic - High.

Detection: Mix 2 ml of sample with 1 ml of 5% xanthydrol in ethanol and 4 ml of glacial acetic acid. Heat in boiling water for 5 minutes. Positive result: solution turns reddish violet. (2, 5).

ISOPRENE $H_2C{:}C(CH_3)CH{:}CH_2$

Synonym: Methyl butadiene.

Description: Clear, colorless, volatile liquid. Mild, aromatic odor. Floats; insoluble. Highly flammable.

Toxicity:

Local - Liquid and vapor are irritant.
Systemic - Moderate. Harmful vapor.
Aquatic - Moderate.

WEAR RESPIRATOR.

Detection: Test for butadiene moiety. See CHLOROBUTADIENE for method.

LACTIC ACID $H_3CCHOHCOOH$

Synonyms: Hydroxypropanoic acid, milk acid.

Description: Colorless to yellowish, odorless, hygroscopic syrup. Sinks; miscible with water. Acid to litmus.

Toxicity:

Local - Mildly irritant.
Systemic - Low to moderate.
Aquatic - Moderate.
Other - May raise BOD.

Detection: 3 steps are required for detection.

(1). Test the sample for FORMALDEHYDE (see that entry for detection kits). This test must be negative, or there is no point to proceeding: FORMALDEHYDE is a hazardous material too.

(2). Evaporate almost to dryness 5 ml of sample. Let cool and add 1 ml of concentrated H_2SO_4. Dilute with 10 ml of water.

(3). Test for FORMALDEHYDE again. Positive result: step (3) is positive for FORMALDEHYDE, but step (1) is negative. (1, 5, 6).

LACTOSE

$C_{12}H_{22}O_{11}$

Synonyms: Milk sugar, saccharum lactis.

Description: Hard white crystalline mass or white powder. Faintly sweet taste; odorless, but readily absorbs odors. Sinks and dissolves.

Toxicity:

Human and aquatic - Practically nontoxic.
Other - Raises BOD.

Detection: Heat 2 ml of sample for one minute with 2 ml of 5% KOH in boiling water bath. Positive result: solution turns red-brown. Many other substances interfere. (1, 4, 6).

LANTHANUM ACETATE $La(C_2H_3O_2)_3$

Synonyms: None.

Description: Water-soluble white powder.

Toxicity:

Human - Low.
Aquatic - High.

Detection: Add 2 ml of sample to 3 ml of dilute acetic acid and 1 ml of 0.01N iodine solution. Positive result: dark blue precipitate. (1, 5). This test for lanthanum is the complement of the lanthanum test for acetate. See AMMONIUM ACETATE for details of method. (1, 5).

LEAD ACETATE $Pb(C_2H_3O_2)_2$

Synonym: Sugar of lead.

Description: White crystals or flakes, when pure: commercial grades are frequently brown or grayish lumps. Sinks and dissolves, but absorbs CO_2 from air, becoming insoluble. Combustible.

Toxicity:

Local - Irritant.
Systemic - Lead is a cumulative poison. Moderate.
Aquatic - High.

Detection: The lead and acetate components must be separately analyzed.

See AMMONIUM ACETATE for acetate methods. To detect lead, mix 1 ml of sample with 2 ml of 5N KCN and 1 ml of concentrated NH_4OH. Add 4 ml of saturated dithizone in CCl_4 solution. Positive result: tetrachloride layer turns red. Ferric ion and phosphate interfere. (1, 5).

N. B. Many natural conditions will bring about the precipitation of lead from solution. Be certain to examine surface bottom deposits. To redissolve metals in bottom solids, boil in aqua regia, filter, discard precipitate, and test filtrate as above.

LEAD ARSENATE $Pb_3(AsO_4)_2$

Synonym: Lead orthoarsenate.

Description: White crystals or heavy white powder. Sinks; almost insoluble. A constituent of several types of pesticides.

Toxicity:

Local - May irritate eyes and skin.
Systemic - Cumulative poison. Moderate.
Aquatic - High.

Detection: The Pb and AsO_4 components must be analyzed separately.

See LEAD ACETATE for Pb methods.

To detect AsO_4, place in a test tube 1 ml of sample, a few grains of metallic zinc, and 5 drops of 6M H_2SO_4. Loosely plug the tube with cotton that has been soaked in 10N HCl. Then cover the tube with filter paper that has been impregnated with 20% $AgNO_3$. Positive result: the filter paper turns brown-black. (1, 5, 6).

LEAD CHLORIDE $PbCl_2$

Synonyms: None common.

Description: White crystals. Sink; slightly soluble.

Toxicity:

Human - A cumulative poison. Moderate.
Aquatic - High.

Detection: See LEAD ACETATE for Pb methods. See AMMONIUM CHLORIDE for Cl methods. Since the Pb is much more important than the Cl, consider dissolving suspect bottom solids in boiling aqua regia to dissolve any lead present.

LEAD NITRATE $Pb(NO_3)_2$

Synonyms: None common.

Description: White crystals that sink and dissolve. The aqueous solution is slightly acid.

Toxicity:

Local - Astringent; irritant in high concentration.
Systemic - Cumulative poison. Moderate.
Aquatic - High.

Detection: The Pb and NO_3 components must be analyzed separately, but the Pb is much more important. See LEAD ACETATE for Pb methods. See AMMONIUM NITRATE for NO_3 methods.

LEAD SULFATE $PbSO_4$

Synonyms: Anglesite, lanarkite.

Description: Heavy, white crystals. Sink; almost insoluble in cold water.

Toxicity: Same as LEAD CHLORIDE.

Detection: See LEAD ACETATE for Pb methods. Treat solid samples with concentrated NaOH, which will dissolve any $PbSO_4$ present as undissolved solid. See ALUMINUM SULFATE for SO_4 methods.

LEAD TETRAETHYL PbR_4

Synonym: Tetraethyl lead.

Includes: **Mixed lead alkyls, e.g., various methyl and ethyl derivatives.**

Description: **Heavy colorless liquid, frequently tinted with a dye. Sweet odor. Sinks; almost insoluble. Decomposes slowly at room temperature. A principal ingredient of motor fuel antiknock compounds.**

Toxicity:

Human - Moderate to high by all routes, including inhalation and skin absorption.

Aquatic - High.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: This substance is just soluble enough to yield a positive response to the Pb method recommended at the LEAD ACETATE entry. For higher concentrations of Pb ion, reflux 2 ml of sample with 5 ml of 6N HNO_3. After a clear solution is obtained, let cool and dilute with 50 ml of water. Then test for Pb as above.

LINOLEIC ACID C_{18} diunsaturated monocarboxylic acid

Synonyms: Linolic acid, octadecandienoic acid, a major ingredient of linseed oil, safflower oil, and tall oil.

Description: Colorless to straw-colored oil, easily oxidized by air. Floats; practically insoluble. The sodium salt is a common soap, very soluble, and a good sudsing agent.

Toxicity:

Human - Practically nontoxic; an edible oil.
Aquatic - Variable, from very low to very high.

Detection: Use unsaturated sites as presumptive test. For a distinct organic phase of supernatant oil, add a few drops of bromine in carbon tetrachloride (about 1%). Positive result: bromine is decolorized. For the dispersed aqueous phase (especially for the sodium salt), add a few drops of 1% aqueous $KMnO_4$. Positive result: the permanganate color disappears. Other unsaturated organics and strong reducing agents interfere. (1, 3).

LITHIUM CHLORIDE LiCl

Synonyms: None.

Description: White deliquescent crystals, very soluble in water. Sharp salty taste.

Toxicity:

Human - Low.
Aquatic - Low.

Detection: Detect Li ion as follows. Mix 2 ml of sample with 10 ml of amyl alcohol. Evaporate the mixture on a hot plate (ABSOLUTELY NO FLAME) until all the water has been expelled. Filter and add the filtrate to 2% ammonium stearate in amyl alcohol. Positive result: precipitate forms. (1, 5, 6).

MALEIC ACID

$HOOCCH{:}CHCOOH$

Synonyms: Cisbutenedioic acid, maleinic acid, toxilic acid, ethylene dicarboxylic acid.

Description: Colorless crystals. Very soluble in water. Faint odor; repulsive astringent taste. Combustible. Acid to litmus.

Toxicity:

Local - Very irritant; sensitizes skin and respiratory tract.
Systemic - Low.
Aquatic - Moderate.

PROTECTIVE CLOTHING ADVISABLE.

Detection: Only concentrated solutions can be reliably detected by pH. For dilute solutions, use test for unsaturation as follows. Add to 5 ml of sample a few drops of 1% $KMnO_4$ (aqueous). Positive result: the permanganate is decolorized. Other unsaturated organics and strong redoxing agents interfere. (1, 3).

MALEIC ANI RIDE $\mathrm{H\overline{C{:}CHC(O)OC}(O)}$

Synonyms: sbutenedioic anhydride, furanedione, toxilic a dride.

Descriptio Colorless needles that sublime readily. Floats, lrolyzing slowly to form MALEIC ACID.

Toxicity: ee MALEIC ACID.

Detectic See MALEIC ACID.

MALTOSE $C_{12}{}_{2}O_{11}$

Synonyms: Maltobiose, malt sugar.

Description: Colorless crystalline solid. Swe aste; odorless. Sinks and dissolves. Com tible.

Toxicity:

Human and Aquatic - Practically nonto
Other - Raises BOD.

Detection: Detect as a sugar. See GLUCOSE for nhods.

METHANETHIOL H_3CSH

Synonyms: Methyl mercaptan, mercaptomethane, thiomethyl alcohol, methyl sulfhydrate.

Description: Colorless, flammable gas with very powerful unpleasant odor (like rotten cabbage) at room temperature. Colorless liquid below 43°F. Floats; slightly soluble. The sodium salt is water soluble; the copper salt is practically insoluble.

Toxicity:

Local - Strong irritant.
Systemic - Low, but high concentrations are narcotic, and the odor is often nauseating.
Aquatic - H [illegible]
Other - Damages plants and phytoplankton as well as fauna.

RESPIRATOR ADVISABLE.

Detection: The unpleasant odor is detectable by the unaided nose down to a few ppm. Simply heating a few ml of sample should be sufficient to produce enough odor for detection. Also see BUTYL MERCAPTAN. (1,4,6). Commercial kits are available for detection; sensitivity range is 5-120 ppm. One supplier is Kitagawa. (1,4 or 5,6).

METHANOL H_3COH

Synonyms: Carbinol, methyl alcohol, wood alcohol, wood spirit.

Description: Clear, colorless, mobile, highly polar liquid. Miscible with water. Flammable (flash point is 54°F). Technical grades may have a repulsive odor.

Toxicity:

Local - May irritate. Dries skin.
Systemic - Low, but high concentrations may cause blindness. Toxic effects by all routes.
Aquatic - Low.

Detection: Commercial kits are available; sensitivity range is 100-10,000 ppm. Suppliers include Kitagawa, MSA, and Scott/Davis. (1 or 2, 5, 6.

As presumptive test, use method for aliphatic alcohols (see BUTYL ALCOHOL). (1, 3, 6).

METHYL ACETATE $H_3CCOOCH_3$

Synonyms: None common.

Description: Colorless, flammable, volatile liquid; fragrant odor. Floats; miscible with water.

Toxicity:

Local - May irritate respiratory tract.
Systemic - Low; may be narcotic in high concentrations.
Aquatic - (Low).

Detection: Commercial kits are available; sensitivity range is 100-3000 ppm. Suppliers include Scott/Davis and Kitagawa. (1, 5, 6).

METHYL ACRYLATE $H_2C{:}CHCOOCH_3$

Synonyms: Acrylic acid methyl ester, methyl propenoate.

Description: Colorless, volatile liquid. Acrid odor. Floats, partially soluble. Polymerizes easily on standing; polymerization is accelerated by heat, light, and peroxides. The monomer is often inhibited by such substances as HYDROQUINONE. The polymer is a transparent, elastic, odorless, insoluble solid; it floats. The polymer is not toxic.

Toxicity: (Monomer only)
Local - Strong irritant and lacrimator.
Systemic - Low; central nervous system effects from inhaling high concentrations of vapor.
Aquatic - (Low).
Other - As the monomer polymerizes, it may coat floating plants, shore structures, and exposed beach areas.

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE.

Detection: Use gross presumptive test for unsaturation; see BENZENE for method. (1, 3). Specific identification requires hydrolysis and GC.

METHYLAMINE H_3CNH_2

Synonyms: Aminomethane, monomethylamine.

Description: Colorless flammable gas that may liquefy on very cold days (20°F). Marketed in liquid form or as a 33% aqueous solution. Strong odor of ammonia. Floats; very soluble. A strong base. The hydrochloride and picrate derivatives are soluble solids.

Toxicity:

Local - Strong irritant.
Systemic - Moderate by inhalation; low by other routes.
Aquatic - High.

Detection: Commercial kits are available; sensitivity range is 10-500 ppm. One supplier is MSA. (1, 5, 6). May also be detected by test for primary amine; see PROPYLAMINE for method.

METHYL AZIDE H_3CN_3

Synonyms: None.

Description: Colorless liquid that gasifies at room temperature. Reacts with water to form METHYL AMINE and nitrogen. Explosive.

Toxicity: See METHYL AMINE.

Detection: See METHYL AMINE.

METHYLETHYL PYRIDINE $(H_3C)(C_5H_3N)(C_2H_5)$

Synonyms: Aldehyde collidine, aldehydine, ethyl picoline, MEP.

Description: Colorless liquid with sharp, biting odor. Floats; slightly soluble. Combustible. The hydrochloride and picrate derivatives are soluble solids; the hydrochloride is colorless, the picrate orange.

Toxicity: See PYRIDINE.

Detection: Test for secondary amine as follows. Prepare reagent by dissolving 0.5 g $NiCl_2$ hexahydrate in 100 ml water. While shaking, add CS_2 to slight excess. Just before testing sample, add 2 ml concentrated NH_4OH to 5 ml of reagent. Then add sample. Positive result: well-defined precipitate. (1, 3).

Specific identification may be accomplished in an improvised laboratory equipped with a UV spectrophotometer.

METHYLISOBUTYL KETONE $(CH_3)_2CHCH_2COCH_3$

Synonyms: Hexone, isopropylacetone, methylpentanone, MIBK.

Description: Colorless, stable, flammable liquid. Pleasant odor similar to camphor. Floats; slightly soluble.

Toxicity:

Local - Irritant.
Systemic - Moderate to high. Some States restrict the use of MIBK because of its toxicity.
Aquatic - (Moderate).
N. B. Many authorities give this compound much lower ratings; the ratings given here are pessimistic and conservative.

Detection: Commercial kits are available; sensitivity range is 5-1000 ppm. Suppliers include Scott/Davis and Kitagawa. (1,5,6).

METHYLMETHACRYLATE $H_2C{:}C(CH_3)COOCH_3$

Synonym: Acrylic resin monomer.

Description: Colorless, clear, volatile, flammable liquid. Sharp, fragrant odor. Floats; slightly soluble. Readily polymerized by light, heat, ionizing radiation, and catalysts. The monomer is usually shipped with a polymerization inhibitor (such as HYDROQUINONE).

Toxicity:

Local - Very irritant.
Systemic - Moderate.
Aquatic - Moderate.

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE.

Detection: Specific identification requires hydrolysis and GC. As presumptive test, use method for detecting unsaturation (see BENZENE for details).

MOLASSES   Mixed sugars

Synonyms: Blackstrap.

Description: The dark, syrup liquid residue after sucrose has been removed from the juice of sugar beet or cane. Composition varies with the extent of sugar removal. Blackstrap molasses (from which no more sugar can be economically removed) contains about 50% sugars, 20% other organics, 10% ash, and 20% water. Sinks and dissolves. Viscosity depends on temperature.

Toxicity:

Human and Aquatic: Practically nontoxic.
Other: Raises BOD; may smother bottom life; may taint the flavor of fish and foul surfaces.

Detection: Treat as mixed sugars. For recommended methods, see GLUCOSE and FRUCTOSE.

MOLYBDIC ANHYDRIDE MoO_3

Synonyms: **Molybdenum trioxide, molybdic oxide or acid anhydride.**

Description: **White powder or granules which may be tinged with yellow. Sinks; very sparingly soluble.**

Toxicity:

Human - Low.

Aquatic - Moderate. More toxic in hard than in soft water.

Detection: **Dissolve suspect solids in 3M HCl. Test filtrate and suspect liquids as follows. Dissolve 0.5 g $N_2H_4:H_2SO_4$ in 2 ml of sample in a test tube. Add 4 ml aqueous methylene blue. Place the test tube in boiling water. Positive result: the methylene blue is decolorized. Nitrates and thiosulfates interfere. (1, 4, 6).**

MONOETHANOLAMINE $HO(CH_2)_2NH_2$

Synonyms: Ethanolamine, MEA, colamine, aminoethanol, hydroxyethylamine.

Description: Colorless, rather viscous, hygroscopic liquid. Ammoniacal odor. A strong base. Miscible with water. Sinks in clean fresh water; may float on heavily polluted or salt or brackish water. Combustible. Absorbs CO_2 and H_2S.

Toxicity:

Local - Irritant, especially to the eyes.
Systemic - Low.
Aquatic - Moderate.

Detection: Mix 1 ml of sample with 1 ml of 15% sulfuric acid. Add to it 2 ml of 5% periodic acid. After 2 minutes, dilute with 5 ml of water. Then test for FORMALDEHYDE and AMMONIUM (see FORMALDEHYDE and AMMONIA for details of methods). (1, 5).

Alternatively, test for primary amine; see PROPYLAMINE for details of method. (1, 3).

The odor of ammonia and the pH may be sufficient for detecting significant concentrations. (1, 3).

MONOISOPROPANOLAMINE $H_3CCH(OH)CH_2NH_2$

Synonyms: Aminopropanol, hydroxypropylamine, MIPA.

Description: Clear, colorless liquid. Slight ammoniacal odor. Floats and dissolves. Combustible.

Toxicity: See MONOETHANOLAMINE.

Detection: See MONOETHANOLAMINE.

MUSTARD GAS $(ClCH_2CH_2)_2S$

Synonyms: Bis(chloroethyl)sulfide, dichloroethyl sulfide, dichlorodiethyl sulfide, HD, sulfur mustard.

Description: Oily liquid. A strong blistering agent, used as a war gas. Weak, sweet odor. Forms prisms at 55°F. Sinks; sparingly soluble. Decomposed by water.

Toxicity:

Local - Powerful vesicant. Burns, blisters, and quickly causes conjunctivitis and blindness. Violently corrosive to all tissues.

Systemic - Highly toxic by all routes, including skin penetration and inhalation.

Aquatic - High.

WEAR RESPIRATOR AND FULL PROTECTIVE CLOTHING.

Detection: Several types of papers, kits, tubes, and crayons for detection are available from the U.S. Army Chemical Corps. (2,5,6). Because mustard gas is decomposed by water, it is possible to test samples for sulfide, using the method given for AMMONIUM SULFIDE. (1,4).

NAPHTHALENE

$C_{10}H_8$, bicyclic

Synonyms: Naphthene, napthalin, tar camphor.

Description: White, crystalline, volatile flakes (a common variety of moth flakes, moth balls, etc.). Strong odor of coal tar. Sinks; practically insoluble. Combustible.

Toxicity:
Local - May irritate skin.
Systemic - Low.
Aquatic - High.

Detection: Use presumptive test for unsaturation; see BENZENE for details. For specific identification, extract the sample with ether, then use UV.

NAPHTHALIC ACID

$C_{10}H_6(COOH)_2$, bicyclic

Synonym: Naphthalene dicarboxylic acid.

Description: White crystals that sink in water; practically insoluble.

Toxicity:

Human - (Low).
Aquatic - Moderate to high.

Detection: See NAPHTHALENE and BENZENE.

NAPHTHENIC ACID $C_6H_{10}COOH$ and similar structures.

Includes: A group of saturated cycloalkyl fatty acids, especially cyclohexanecarboxylic acid (hexahydrobenzoic acid).

Description: The commercial grade is usually a mixture of acids; dark, foul-smelling, corrosive (to metals) solids and sludges. Usually sink (depends on commercial grade and density of the water); slightly soluble. Pure cyclohexanecarboxylic acid is a colorless solid, which may be odorless or slightly smelling of valerian (very unpleasant); it may sink or float, and is slightly soluble.

Toxicity:

Human - Low.
Aquatic - Moderate to high.

Detection: There is no suitable method for detection at water's edge. In an improvised laboratory, potentiometric titration and GC may help identification.

NAPHTHOL

$C_{10}H_7OH$, bicyclic

Synonym: Hydroxynaphthalene.

Description: Shiny white powder or bulky leaflets which darken on exposure to sunlight and with age. Faint odor of phenol. Combustible. Sinks; slightly soluble.

Toxicity:

Local - May produce peeling and discoloration of skin.
Systemic - Low.
Aquatic - High.
Other - Small amounts taint the flavor of fish.

Detection: Can test for unsaturation (see BENZENE) or for aromatic alcohol, as follows. Combine 2 ml of sample with 5 ml of reagent (a 10% solution of ceric ammonium nitrate in 2N nitric acid). Positive result: greenish brown to brown precipitate. (1, 3). To detect the beta isomer, mix 1 ml of the sample with 5 ml of 0.1% malic acid in concentrated sulfuric acid. Positive result: the beta isomer gives a yellow solution that fluoresces blue. (1, 5). To detect the alpha isomer, mix 2 mg of acetanilide with 1 ml of 10% sodium nitrite and 1 ml of concentrated HCl. After letting stand for 1 minute, add 1 ml of 10% NaOH and 10 mg of urea. Then add 2 ml of ethanol and 1 ml of sample. Positive result: the alpha isomer turns the solution red or orange. (1, 5).

NAPHTHYLAMINE

$C_{10}H_7NH_2$, bicyclic

Synonyms: Aminonaphthalene, naphthalidine.

Includes: Both the alpha and beta isomers and their common derivatives.

Description: White to reddish crystalline solid which reddens on exposure to air and light. Sinks, but may float in polluted, salt, or brackish water. Slightly soluble. The HCl derivative is quite soluble, and the acetate derivative is very soluble. All the derivatives are sensitive to light and exposure.

Toxicity:

Human - A KNOWN CARCINOGEN, outlawed in at least one State. Acute toxicity is moderate.
Aquatic - (Moderate).

WEAR FULL PROTECTIVE CLOTHING; RESPIRATOR ADVISABLE.

Detection: Several methods are available.

(I). Naphthylamine reduces warm ammoniacal silver nitrate solution. Positive result: precipitate. (1, 5).

(II). Extract samples with chloroform and separate. Irradiate the chloroform extract under a UV lamp for 10 minutes. Positive result: the extract turns red or orange. (1, 5).

(III). Test for primary amine; see PROPYLAMINE for details of method. (1,3).

NEUTRAL SURFACTANTS RSO_4Na

Includes: A wide variety of neutral detergents, all the sodium salts of sulfated fatty alcohols derived from various plant and animal sources. Two of the most important are sodium lauryl sulfate (although the article of commerce is a mixture of alkyl sulfates, with the laurate predominating) and n-octyl sodium sulfate (the so-called Gardinol family of detergents). Some of the most important brand names are Gardinol, Duponol, Modinal, Aurofix, Moprofix, Tergavon, Sandopan, Cyclopan, Cyclanon, Sapidan, Lissapol, Teepol, and Irium.

Description: White or cream colored crystals, flakes, and powders. Faint fatty odor. Smooth feel. Neutral to litmus. Sink and dissolve readily, giving an opalescent soapy solution. These common wetting agents and detergents are widely used as ingredients of toothpastes, cosmetics, etc.

Toxicity:

Human: Low.
Aquatic - Reports vary; sometimes High, usually Low.
Other - Can cause extensive foaming and sudsing.

Detection: Mix sample with 10 ml of chloroform and 20 ml of ammonium hexathiocobaltate reagent (200 mg ammonium thiocyanate and 30 g $Co(NO_3)3$ in one liter of water). Positive result: blue chloroform layer. (1, 4).

NICKEL AMMONIUM SULFATE $NiSO_4 \cdot (NH_4)_2SO_4$

Synonyms: Ammonium nickel sulfate, ammonium disulfatonickelate.

Description: Bluish-green crystalline solid that sinks and dissolves. Concentrated solutions are slightly acidic.

Toxicity:

Local - Irritant to skin.
Systemic - Low, but may be carcinogenic.
Aquatic - High.
N. B. Nickel compounds are highly toxic to fish and zooplankton. Soluble nickel compounds spilled in water may be precipitated by such natural phenomena as absorption of CO_2, hydroxylation, and reactions with sulfides. Collect suspect solids and bottom samples and boil them with HNO_3 to redissolve the nickel, which may then be detected by the methods given below.

Detection: Test for the Ni, NH_4, and SO_4 components separately. Test for nickel as follows. Drop concentrated NH_4OH into 2 ml of sample until the solution is basic. Filter if a precipitate forms. Add 1 ml alcoholic saturated dimethylglyoxime to the filtrate. Positive result: a pink or red precipitate. Ferrous, cupric, and cobaltous ions interfere. (1, 4).

See AMMONIUM ACETATE for NH_4 tests.
See ALUMINUM SULFATE for SO_4 tests.

NICKEL CHLORIDE $NiCl_2$

Synonym: Nickelous chloride.

Description: Golden powder, brown scales, or green crystals, depending on degree of hydration and technical purity. All forms are deliquescent. Sinks and dissolves. The aqueous solution is mildly acidic (pH of 4).

Toxicity:

Human - Low.
Aquatic - High.

Detection: See NICKEL AMMONIUM SULFATE for Ni methods.

See AMMONIUM CHLORIDE for Cl methods.

NICKEL NITRATE $Ni(NO_3)_2$

Synonym: Nickelous nitrate.

Description: Green, deliquescent crystals that sink and dissolve, giving a mildly acidic solution (pH of 4). A strong oxidizing agent.

Toxicity:

Local - Irritant.
Systemic - Low.
Aquatic - High.
Other - Even if the Ni should be precipitated from solution, the NO_3 may stimulate plant growth.

Detection: See NICKEL AMMONIUM SULFATE for Ni methods.

See AMMONIUM NITRATE for NO_3 methods.

NICKEL SULFATE $NiSO_4$

Synonym: Nickelous sulfate.

Description: Crystalline solid, which may be yellowish, bluish, or clear green, depending on degree of hydration. Sinks and dissolves. The solution has a sweet, astringent taste. The solution is mildly acidic (pH of 4.5).

Toxicity:

Local - Irritant.
Systemic - Low.
Aquatic - High.

Detection: See NICKEL AMMONIUM NITRATE for Ni methods.

See ALUMINUM SULFATE for SO_4 methods.

NITRIC ACID

HNO_3

Synonyms: Aqua fortis, azotic acid, engraver's acid; ingredient of mixed acid, nitrating acid, aqua regia, nitrohydrochloric acid, nitromuriatic acid, chloronitrous acid, chloroazotic acid.

Description: Clear to light-brown liquid; may be yellowish and fuming. Suffocating odor; caustic and corrosive. Decomposes in strong light and heat, turning reddish. A very strong oxidizing agent, and one of the strongest acids. Extremely reactive.

Toxicity:

Local - The liquid causes severe burns. The vapor is strongly irritant, and may cause fatal lung injury.
Systemic - Moderate to high.
Aquatic - Moderate to high.
Other - Corrosive to nearly everything it touches; look for extensive corrosion damage. Nitrates are plant nutrients; look for growth stimulation of plants downstream.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Test first with pH indicator or meter for an acid (1-3, possibly 6). Then test for NO_3 ion; see AMMONIUM NITRATE for method.

NITRIC OXIDE NO

Synonyms: Mononitrogen monoxide, nitrogen monoxide.

Description: Colorless gas or liquefied gas. Immediately on contact with air, NO is converted into the highly toxic brown NITROGEN DIOXIDE, NITROGEN TETROXIDE, or both. Turns brown in air. The gas and its oxidation products are soluble in water, giving NITRIC ACID and related acids.

Toxicity: See NITROGEN DIOXIDE and NITRIC ACID. Look for corrosion effects.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Commercial kits are available for detecting NO; sensitivity range is 0.5-1000 ppm. (2,5,6). Also see NITRIC ACID. pH is a good indicator of aquatic hazard.

NITROANILINE $H_2NC_6H_4NO_2$

Synonym: **Nitraniline.**

Description: **Yellow to orange crystalline solid. Discolors in strong light. Sinks; slightly soluble.**

Toxicity:

Local - **Irritant.**
Systemic - **Moderate to high by all routes, including inhalation and absorption through intact skin.**
Aquatic - **Moderate.**

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: **Specific identification of the isomers can be accomplished by UV spectroscopy. (1, 5, 6). Gross presumptive tests include unsaturation (see BENZENE for method) and primary amine (see PROPYLAMINE for method).**

NITROBENZENE $C_6H_5NO_2$

Synonyms: Nitrobenzol, oil of mirbane.

Description: Colorless to pale yellow oily liquid; freezes at 43°F to give yellow crystals. Odor of almonds. Sinks; slightly soluble. Forms an explosive vapor layer above the water surface.

Toxicity:

Local - Irritant, especially to the eyes.
Systemic - Moderate by all routes, including inhalation and absorption through intact skin.
Aquatic - High.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Extract 10 ml of sample with 5 ml of ether and evaporate the ether on a steam bath. Carefully add 3 ml of concentrated H_2SO_4 to the residue. Positive result: solution turns yellow. Nitrotoluene (which is also a toxic industrial material) interferes. (1, 5).

NITROCHLOROBENZENE $ClC_6H_4NO_2$

Synonym: Chloronitrobenzene.

Description: Combustible yellow crystalline solid. Sinks; Virtually insoluble.

Toxicity:

Local - Irritant.
Systemic - Moderate.
Aquatic - High to moderate.

PROTECTIVE CLOTHING ADVISABLE.

Detection: The only suitable test for use at water's edge is the presumptive test for unsaturation (see BENZENE for method). In an improvised laboratory, use GC for identification.

NITROCRESOL $NO_2(CH_3)C_6H_3OH$

Synonym: Methylnitrophenol.

Description: Yellow, combustible, crystalline solid. Sinks; slightly soluble.

Toxicity:

Human - Moderate to high by all routes.
Aquatic - (Moderate).

PROTECTIVE CLOTHING ADVISABLE.

Detection: For gross presumptive method, test for unsaturation (see BENZENE for method). In an improvised laboratory, use UV spectroscopy.

NITROGEN DIOXIDE NO_2

Synonyms: None common.

Description: Reddish brown gas, liquid below 72°F. Suffocating sharp odor. The commercial brown liquid under pressure is often called "nitrogen tetroxide" or "N-two-O-four", although in actuality it is an equilibrium mixture of NO_2 and the colorless N_2O_4. The liquid sinks and dissolves, forming NITRIC ACID and NITRIC OXIDE. The gas dissolves, forming the same products. The gas is an insidious deadly poison.

Toxicity: See NITRIC ACID.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Commercial kits are available; sensitivity range is 0.1-1000 ppm. Suppliers include Davis, Kitagawa, MSA, and Scott/Davis. (2, 5, 6).

NITROGEN TETROXIDE N_2O_4

Synonyms: None common.

Description: This colorless gas is very unstable, and spontaneously decomposes into NITROGEN DIOXIDE.

Toxicity: See NITROGEN DIOXIDE and NITRIC ACID.

Detection: See NITROGEN DIOXIDE and NITRIC ACID.

NITROPHENOL $HOC_6H_4NO_2$

Synonyms: None common.

Description: Yellow crystals that sink in water; slightly soluble. A widely used pH indicator for acids. Depending on the isomer, the indicator solution turns from colorless in strong acids to bright yellow in weak acids.

Toxicity:

Human - Moderate to high.
Aquatic - Moderate.

Detection: Only the proposed presumptive test is suitable for use at water's edge; perform test for unsaturation (see BENZENE for method). In an improvised laboratory, use *UV* spectroscopy. For another presumptive test, see comments above under "Description"; this test is based on nitrophenol as a pH indicator, but the color change is not sharp and CO_2 interferes.

NITROPROPANE

$C_3H_7NO_2$

Synonyms: None common.

Description: Colorless, flammable liquid. May float or sink depending on the dissolved solids in water. Slightly soluble.

Toxicity:

Human - Low.
Aquatic - (Low).

Detection: Commercial kits are available; sensitivity range is 5-150 ppm. One supplier is MSA. (1, 5, 6).

NITROUS ACID HNO_2

Synonyms: None common.

Description: A weak acid, known only in solution, which is pale blue. Changes rapidly in water to NITRIC OXIDE and NITRIC ACID. Forms stable, soluble nitrites with several common cations, including Na, K, and Ca.

Toxicity: Similar to NITRIC ACID, but lower. Nitrous acid is a known mutagen, and may produce genetic effects.

Detection: See NITRIC OXIDE and NITRIC ACID.

Commercial kits for nitrite or nitrate/nitrite detection are available from Lamotte, Taylor, Hellige, and Hach. Sensitivity range is 0.1 - 1000 ppm. (1,5,6).

NITROUS OXIDE N_2O

Synonyms: Dinitrogen monoxide, factitious air, hyponitrous anhydride, laughing gas.

Description: Colorless asphyxiant gas. Slightly sweet taste and odor. Soluble. Supports combustion, but stable and inert at room temperature. Commercial form is liquefied gas.

Toxicity:

Human - Low.
Aquatic - (Low).
Other - The water solution of nitrous oxide is a mildly corrosive acid.

Detection: Commercial kits are available; sensitivity range is 1.5-2000 ppm. One supplier is Scott/Davis. (Z, 5, A).

NITROXYLOL $(CH_3)_2C_6H_3NO_2$

Synonym: Nitroxylene.

Description: Yellow liquid or yellowish crystalline solid, depending on the isomeric form. Sinks; practically insoluble.

Toxicity:

Local - Irritant.
Systemic - Moderate to high.
Aquatic - (Moderate to high).

Detection: At water's edge, even the gross presumptive test for unsaturation (see BENZENE for method) may fail. In an improvised laboratory, use GC.

OCTYL ALCOHOL $C_8H_{17}OH$

Synonyms: Octanol, heptyl carbinol, capryl alcohol, methylhexyl carbinol.

Description: There are 2 common isomers, which have somewhat different properties. The n isomer is a colorless combustible liquid with a penetrating aromatic odor. Floats, very insoluble. The sec isomer is a colorless, refractive, combustible, oily liquid which floats and is slightly soluble. Its odor is much less pronounced. Both isomers are used as antifoaming agents.

Toxicity:

Human: Low.
Aquatic: Moderate.

Detection: Test for aliphatic alcohol (see METHYL ALCOHOL for method). In an [illegible] laboratory, use IR, the [illegible].

OLEIC ACID $H_3C(CH_2)_7CH:CH(CH_2)_7COOH$

Synonyms: Octadecenoic acid, Turkey red oil.

Description: This acid is a component of all natural fats and some oils. Commercial grades are yellow to red oily liquids that darken on exposure to air and solidify at about 40°F. Smell like lard. Combustible. Floats; practically insoluble. Purified grades are nearly colorless and odorless; they are used in making soft soaps and oil solvents.

Toxicity:

Human - Low.
Aquatic - (Low; but there have been reports of high fish toxicity from sodium oleate.)

Detection: Use presumptive test for unsaturation (see BENZENE for methods). For more precise identification, extract the sample with ether, evaporate the ether, then determine the iodine value of the residue or use GC. These methods are more suitable to an improvised laboratory, than to a test at water's edge.

OXALIC ACID

HOOCCOOH

Synonym: Ethanedioic acid.

Description: Transparent, colorless crystals. Sinks and dissolves. Acid to litmus. Corrosive.

Toxicity:

Local: Strongly irritant.
Systemic: Moderate.
Aquatic: Moderate.

WEAR PROTECTIVE CLOTHING.

Detection: Use pH indicator for strong acid (1, 3). Then mix 1 ml of sample with 1 ml of 1:9 sulfuric acid. Add slowly and carefully 5 mg of metallic zinc. Let stand for 30 minutes. Add slowly 2 ml of 0.01% 2,7-dihydroxynaphthalene in 1:1 sulfuric acid. Heat in boiling water for 5 minutes. Positive result: solution turns red. (1,5,6).

OXYPROPIONITRILE $O(CH_2CH_2CN)_2$

Synonym: ODPN.

Description: Colorless, combustile liquid that sinks and dissolves.

Toxicity:
Human - Low.
Aquatic - Low.

Detection: There is no suitable method for detection at water's edge. In an improvised laboratory, use GC.

PARAFORMALDEHYDE $HO(CH_2O)_nH$

Synonym: Paraform.

Includes: sym-trioxane. PARAFORMALDEHYDE is a polymer of FORMALDEHYDE in which n is 8-100; in this listing we include all polymeric forms of FORMALDEHYDE.

Description: PARAFORMALDEHYDE is a white solid with a slight odor of formaldehyde. Commercially available as flakes or powders, used in germicides. Sinks, but solubility depends on the size of the polymer; lower polymers are much more soluble than higher polymers. Combustible. sym-trioxane is a white crystalline solid with a pronounced formaldehyde odor; it sinks and dissolves.

Toxicity:

Local - Irritant.
Systemic - Moderate.
Aquatic - Moderate to low, depending on solubility.

Detection:

(I). Detect as FORMALDEHYDE (see that entry for method).

(II). Alternatively, apply a general test for aldehydes, as follows. Add 2 ml of Benedict's solution to 5 ml of sample. Benedict's solution is made as follows. Combine 17.3 g of hydrated cupric sulfate, 173.0 g of sodium citrate, and 100 g of anhydrous sodium carbonate; add distilled water to make 1 liter. Positive result: all aldehydes give a yellow to green precipitate. (1, 4).

(III). Alternatively, apply the following test for aldehydes. Mix 2 ml of sample with 2 ml of dilute sulfurous acid and 2 ml of 0.1% fuchsin in sulfurous acid. Positive result: solution turns violet or blue. (1, 4).

PENTANAL $H_3C(CH_2)_3CHO$ or $(H_3C)_2CHCH_2CHO$

Synonyms: Amyl aldehyde, isovaleral, isovaleraldehyde, isovaleric aldehyde, methylbutyraldehyde, valeral, valeraldehyde, valeric aldehyde.

Description: Clear, colorless, flammable liquid. Floats; slightly soluble. Isovaleraldehyde has a strong smell similar to apples.

Toxicity:

Human - Low.
Aquatic - Low.

Detection: Detect as aldehyde; see PARAFORMALDEHYDE for methods.

PENTANE C_5H_{12}

Synonym: Amyl hydride.

Description: Colorless, flammable liquid. Pleasant odor. Floats; soluble. Used in pesticides.

Toxicity:

Human - Slight.
Aquatic - Moderate.

Detection: Commercial kits are available for detecting hydrocarbons. Scott/Davis is one supplier. (1, 4, 6).

PENTANOL $C_5H_{11}OH$

Synonyms: Amyl alcohol, methyl propyl carbinol, methylbutyl alcohol, ethylpropanol, diethyl carbinol, methylbutanol, dimethyl ethyl carbinol, amylene hydrate.

Includes: Fusel, which is a mixture of alcohols, largely pentanols.

Description: The various isomers of pentanol have somewhat different properties. All are colorless, flammable, volatile liquids that float on water. All are flotation agents. The tert isomer smells like camphor; other isomers have a mild odor. Depending on the isomer, pentanol is slightly to very soluble. Fusel oil is an oily, volatile liquid that floats and is slightly soluble.

Toxicity:

Human - Low to moderate, depending on isomer.
Aquatic - Moderate.

Detection: Detect as aliphatic alcohol; see BUTYL ALCOHOL for method.

PENTENE C_5H_{10}

Synonyms: Amylene, propylethylene, methylethylethylene.

Description: There are several isomers. Flammable, clear liquids. Float; practically insoluble. trans-2-pentene is a polymerization inhibitor, and may be mixed with active monomers (e.g., acrylates).

Toxicity:

Human - (Low).
Aquatic - Moderate to high.

Detection: Test for unsaturation; see BENZENE for method.

PHENOL C_6H_5OH

Synonyms: Carbolic acid, cresylic acid, hydroxybenzene, phenic or phenylic acid.

Description: Colorless to pink crystalline solid or fluid. Reddens on exposure to air. Characteristic odor and taste of disinfectants. Sinks and dissolves readily.

Toxicity:

Local - Irritant, caustic to skin.
Systemic - Moderate to high by ingestion.
Aquatic - High for almost all forms of aquatic life.
Other - Subtoxic amounts may taint the flavor of fish.

WEAR PROTECTIVE CLOTHING.

Detection: Commercial kits are available; sensitivity range is 0.5-10 ppm. One supplier is Scott/Davis. (2,5,6).

PHENYLCARBYLAMINE CHLORIDE $C_6H_5NCCl_2$

Synonyms: None common.

Description: A chemical warfare agent. Pale yellow oily liquid. Mildly volatile; odor like onions. Sinks; practically insoluble.

Toxicity:

Local - Extremely irritating to skin and mucous membranes.
Systemic - High.
Aquatic - (High).

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Kits are available from the U.S. Army Chemical Corps.

PHOSGENE

$OCCl_2$

Synonyms: Carbon oxychloride, carbonyl chloride, chloroformyl chloride.

Description: Colorless gas that condenses at about 32°F to a clear, colorless, fuming liquid. Suffocating odor; in great dilution with air, smells like moldy hay. Sinks; slightly soluble in water, and slowly hydrolyzed to yield, CO_2 and HYDROCHLORIC ACID. Used in chemical synthesis and in chemical warfare.

Toxicity:

Local - Insidious irritant, especially to respiratory tract.
Systemic - High, especially by inhalation.
Aquatic - (High).

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Several commercial kits are available; sensitivity range is 0.1-75 ppm. Suppliers include MSA, Kitagawa, and Scott/Davis. (2, 5, 6). Alternatively, the following method may be used. Paper soaked in an alcoholic or carbon tetrachloric solution containing 10% of a mixture of equal parts of p-dimethylaminobenzaldehyde and colorless diphenylamine, then dried, will turn from yellow to deep orange in the presence of the maximum allowable concentration of phosgene. (2, 5, 6).

PHOSPHORIC ACID H_3PO_4 and $(HPO_3)_x$

Synonyms: None common.

Includes: The meta and ortho isomers.

Description: The o isomer is a clear, colorless, sparkling, syrupy liquid or transparent crystalline solid, depending on concentration and temperature. Pleasing acid taste in dilution (like soda water). Sinks; miscible with water. The m isomer is a glassy, transparent, deliquescent mass. It sinks and dissolves easily. The m isomer slowly converts to the o form. Both isomers are corrosive to ferrous metals and alloys; both are acid to litmus.

Toxicity:

Local - Concentrated solutions (75%) are irritant.
Systemic - Low.
Aquatic - High.

Detection: Test first with pH indicator for acid. Then test for phosphate ion; see AMMONIUM PHOSPHATE for method.

PHOSPHORUS P

Synonyms: None common.

Includes: White, black, and red forms.

Description: White (or yellow) phosphorus is a crystalline, waxy, volatile, transparent solid. Darkens on exposure to light. It glows in the dark. Risk of fire and explosion. Sinks; insoluble. Red phosphorus is a red to violet powder. Much less reactive than the white form. Sinks; insoluble.

Toxicity:

N. B. The following ratings are for white phosphorus; the red and black forms are practically non-toxic except when they contain the white form as an impurity.

Local - Severe burns and irritation.
Systemic - Moderate to high: corrosive and toxic.
Aquatic - High.

Detection:

1. White phosphorus. Keep under water and handle only with forceps. Add 1N nitric acid to the sample, which converts it to PHOSPHORIC ACID. See PHOSPHORIC ACID and AMMONIUM PHOSPHATE.

2. Red or black phosphorus. Add 3N nitric acid to the sample, which converts it to PHOSPHORIC ACID. See PHOSPHORIC ACID and AMMONIUM PHOSPHATE.

PHOSPHORUS OXYCHLORIDE $POCl_3$ and $P_2O_3Cl_4$

Synonym: Phosphoryl chloride.

Description: Colorless, fuming liquid; biting odor. Sinks; decomposes on contact with water to HYDROCHLORIC ACID and PHOSPHORIC ACID.

Toxicity:

Local - Extremely irritating and caustic. Severe respiratory damage.

Systemic and Aquatic - See HYDROCHLORIC ACID and PHOSPHORIC ACID.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: See HYDROCHLORIC ACID and PHOSPHORIC ACID and AMMONIUM PHOSPHATE.

PHOSPHORUS PENTASULFIDE P_2S_5

Synonyms: Phosphoric sulfide, phosphorus persulfide, thiophosphoric anhydride.

Description: Light yellow or greenish crystalline masses. Very hygroscopic. Peculiar odor similar to H_2S. Ignites and burns by friction. Decomposed by moist air and water to form H_2S and PHOSPHORIC ACID. Used in manufacture of matches and ignition compounds.

Toxicity:

Local - Strong irritant.
Systemic - (Moderate).
Aquatic - High.

Detection: Detect as PHOSPHORIC ACID and sulfide (see AMMONIUM SULFIDE).

PHOSPHORUS TRICHLORIDE PCl_3

Synonym: Phosphorus chloride.

Description: Clear, colorless, fuming liquid. Decomposes rapidly in moist air and water to form HYDROCHLORIC ACID and phosphorous acid. Sinks and decomposes.

Toxicity:

Local - Intensely irritant and corrosive.

Systemic and Aquatic - See PHOSPHORIC ACID and HYDROCHLORIC ACID.

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE

Detection: See PHOSPHORIC ACID and HYDROCHLORIC ACID. Although the ultimate hydrolytic and oxidation products of PCl_3 are HYDROCHLORIC and PHOSPHORIC ACIDS, phosphorous acid is formed first, then slowly oxidized to H_3PO_4. To detect phosphorous acid, add to the sample 0.1N iodine a little at a time. Positive result: the iodine solution is decolorized. (1,4). Many substances interfere.

POLYGLYCOL ETHER HO-R-O-R'-O-R''-OH

Synonym: Polyether glycol.

Description: A large family of polyalkyl glycols, including mono- and dialkyl ethers of all types. They are largely clear, colorless liquids, often hygroscopic, and dissolve readily in water. They are common solvents and antifeezes of low toxicity. They often have a pleasant aromatic or fruity odor and a slightly sweet taste. They are important in water pollution primarily because of the large oxygen demand they make: a major BOD problem would result from any sizable spill.

Toxicity:

Human and Aquatic - Low.
Other - Raises BOD.

Detection: Mix 10 ml of sample with 2 ml of 1:4 HCl and 2 ml of 10% $BaCl_2$ solution. Add 2 ml of 10% phosphomolybdic acid. Let stand for 30 minutes. Positive result: green precipitate. (1,4,6). To be more specific, collect this precipitate, filter it, and wash it first with 3 ml of 1:100 HCl, then with 7 ml of water. Dissolve the precipitate in a mixture of 3 ml concentrated H_2SO_4, 1 ml concentrated HNO_3, and 1 ml of 70% perchloric acid. Add 20 ml of water and 2 ml of 40% NaOH solution. Finally, add 5 ml of 5% phenylhydrazine in 1:20 H_2SO_4. Positive result: solution turns blue. (2,4,6).

POTASSIUM CHROMATE K_2CrO_4

Synonym: Neutral potassium chromate.

Description: Lemon yellow crystals. Sink and dissolve. Alkaline to litmus. Corrosive.

Toxicity:

Local - Strongly irritant.
Systemic - High by ingestion.
Aquatic - High to moderate.

Detection: See AMMONIUM CHROMATE for detecting CrO_4.

The K ion is so common, background may be a severe detection problem. A simple method for detecting K is as follows. Mix 1 ml of sample with 1 ml of ethanol and 1 ml of reagent (0.5 g of sodium cobaltinitrite in 3 ml of water). Positive result: yellow crystals form.

POTASSIUM HYDROXIDE KOH

Synonyms: Caustic potash, potash hydrate, lye.

Description: Deliquescent, white solid. Absorbs water and CO_2 from air. Sinks and dissolves easily. A very corrosive alkali. Strongly alkaline to litmus.

Toxicity:

Local - Very corrosive and irritating. Burns tissues.
Systemic - A corrosive poison.
Aquatic - Moderate to high.

WEAR PROTECTIVE CLOTHING.

Detection: Test with pH indicator for strong base. (1, 5, possibly 6). Then test for K ion (see POTASSIUM CHROMATE for method).

POTASSIUM PERMANGANATE $KMnO_4$

Synonym: Chameleon mineral.

Description: Dark purple crystals with metallic sheen. Sweet, with astringent aftertaste. Sinks and dissolves, giving an intense, dark violet solution. A powerful oxidizing agent which reacts with organic materials. Widely used as a disinfectant and bleach.

Toxicity:

Local - Irritant. Caustic in high concentrations.
Systemic - Low.
Aquatic - High for fish and algae.

Detection: If sample is cloudy or muddy, filter it. If the filtrate is not pink or violet, permanganate is not present in detectable quantity. If the solution is pink or purple, add several drops of sample to 3% solution of hydrogen peroxide in 1:10 HCl. Positive result: the purple color is bleached.

POTASSIUM CYANIDE **KCN**

Synonyms: Cyanide of potassium, cyanide of potash.

Description: White, deliquescent, crystalline solid which is gradually decomposed by moisture and CO_2. Readily soluble, but decomposes in water and light to yield POTASSIUM HYDROXIDE and HYDROCYANIC ACID. Violently poisonous, and forms poisonous vapors from solution. Concentrated solutions are strongly alkaline.

Toxicity:

Local - Strong solutions are caustic to skin.
Systemic - High. Can be absorbed through injured skin.
Aquatic - High.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: See POTASSIUM CHROMATE for detecting K.

See BARIUM CYANIDE and HYDROCYANIC ACID for detecting CN.

POTASSIUM DICHROMATE $K_2Cr_2O_7$

Synonyms: Potassium bichromate, red potassium chromate.

Description: Bright scarlet crystals. Bitter metallic taste. Sinks and dissolves freely. Strong oxidizing agent; reacts strongly with organic materials. Corrosive. Concentrated solutions are acid to litmus.

Toxicity:

Local - Strong irritant and caustic.
Systemic - Moderate; a corrosive poison.
Aquatic - Variable; usually moderate, but may be very high or rather low.

Detection: See POTASSIUM CHROMATE for detecting K.

See AMMONIUM CHROMATE for detecting chromate and dichromate ions.

PROPANAL C_2H_5CHO

Synonyms: Propionaldehyde, propyl aldehyde, propionic aldehyde.

Description: Clear, colorless, very flammable liquid. Suffocating odor. Floats and dissolves.

Toxicity:

Local - Irritant.
Systemic - Moderate by inhalation, low by ingestion.
Aquatic - (Moderate or low).
Other - Raises BOD.

WEAR RESPIRATOR.

Detection: Detect as an aldehyde; see PARAFORMALDEHYDE for methods.

PROPANOIC ACID H_3CCH_2COOH

Synonyms: Methylacetic acid, propionic acid.

Description: Combustible, colorless, oily liquid. Sharp rancid odor. Floats and dissolves. The calcium salt is a common food preservative.

Toxicity:

Local - Skin irritant.
Systemic - Low.
Aquatic - Moderate.

Detection: There is no suitable method for detection at water's edge. In an improvised laboratory, use GC with hydrophobic column (e.g., Teflon).

PROPANOIC ANHYDRIDE $(CH_3CH_2CO)_2O$

Synonyms: Methylacetic anhydride, propionic anhydride.

Description: Combustible, colorless liquid. Sharp rancid odor. Floats or sinks depending on temperature and solids content of water. Dissolves, and is converted to PROPANOIC ACID.

Toxicity:
See PROPANOIC ACID.

Detection:
See PROPANOIC ACID.

PROPYL ALCOHOL C_3H_7OH

Synonyms: Propanol, isopropanol, isopropyl alcohol, dimethyl carbinol.

Description: Colorless, flammable liquid, completely miscible with water. The n isomer smells like ETHYL ALCOHOL; the iso form has the characteristic smell of rubbing alcohol, of which it is the principal ingredient.

Toxicity:

Local - Practically none; may be slightly irritating.
Systemic - Low for the n isomer; moderate for the iso form.
Aquatic - Moderate.

Detection: Commercial kits are available; sensitivity range is 100-1000 ppm. Suppliers include MSA and Scott/Davis. (1, 5, 6).

Alternatively, detect as an aliphatic alcohol; see BUTYL ALCOHOL for method.

PROPYLAMINE $C_3H_7NH_2$

Synonym: Aminopropane.

Description: Colorless, volatile, flammable, liquid. Amine odor. Floats and dissolves.

Toxicity

Local - Strongly irritant as liquid and vapor. Burns skin.
Systemic - Moderate by all routes, especially inhalation.
Aquatic - Moderate.

Detection: Test as a primary amine, as follows. Mix 2 ml of sample with 5 ml of 0.1M benzenesulfonyl chloride in 10% aqueous NaOH. There should be no precipitation at this point; if a precipitate forms, filter it out. Acidify the filtrate with dilute HCl. Positive result: precipitate forms. (1,3).

For specific identification (which cannot be accomplished at water's edge), use GC with a hydrophobic column.

PROPYLENE GLYCOL $H_3CCH(OH)CH_2OH$

Synonyms: Dihydroxypropane, propanediol, methylethylene glycol, methyl glycol, trimethylene glycol.

Description: Colorless viscous, stable, combustible, hygroscopic liquid. No taste or odor. Slowly sinks: may float on salt or brackish water. Very miscible.

Toxicity:

Human and Aquatic - Low.
Other - Raises BOD.

Detection: Mix 5 ml of sample with 2.5 ml of 6.6% sodium periodate in a test tube. Let stand for 20 minutes. Cool to 32°F, then add 1 ml of saturated KNO_3 solution. Then add 1 ml of saturated piperazine hydrate solution and 0.5 ml of 4% sodium nitroprusside. Positive result: solution turns blue. (1, 5, 6).

PROPYLENE OXIDE $H_3C\overline{CHCH_2O}$

Synonyms: Propene oxide, epoxypropane.

Description: Clear, colorless flammable liquid. Smells like ether. Floats; fairly soluble.

Toxicity:

Local - May irritate.
Systemic - Moderate to low.
Aquatic - (Low).
Other - Raises BOD.

Detection: Commercial kits are available; sensitivity range is 100-4000 ppm. Kitagawa is one supplier. (1, 5, 6).

PYRIDINE $\overline{N(CH)_4}CH$

Synonyms: None common.

Description: Colorless to slightly yellow liquid. Sharp, disagreeable odor, burning taste. A weak base. Floats; completely miscible.

Toxicity:

Local - Irritant.
Systemic - Low.
Aquatic - Moderate.

Detection: Commercial kits are available; sensitivity range is 2-50 ppm. One supplier is MSA. (1 or 2, 5, 6).

Alternatively, test for secondary amine as follows. Prepare reagent by dissolving 0.5 g $NiCl_2$ hexahydrate in 100 ml of water. While shaking, add CS_2 to slight excess. Just before testing sample, add 2 ml of concentrated NH_4OH to 5 ml of reagent. Then 2 ml of sample. Positive result: a well-defined precipitate. (1, 3).

PYROCATECHOL $C_6H_4(OH)_2$

Synonyms: Benzenediol, catechol, dihydroxybenzene, pyrocatechin.

Description: Colorless crystals that turn brown in light and air, particularly when moist. Sinks and dissolves. Aqueous solutions quickly turn brown. Reduces ammoniacal silver nitrate and Fehling's solution; forms a definite compound with boric acid.

Toxicity:

Local - Irritant and caustic.
Systemic - Moderate.
Aquatic - High.

Detection: Simple tests include unsaturation (see BENZENE for method), and addition of dilute ferric chloride, which turns pyrocatechol solutions green. (1, 4).

A more specific test: Mix 2 ml of sample with 2 ml of 1% osmium tetroxide and 2 ml of 0.4% sodium carbonate solution. Positive result: solution turns reddish violet. (1, 5). Gallic acid and pyrogallol interfere.

PYROGALLOL $C_6H_3(OH)_3$

Synonyms: Benzenetriol, pyrogallic acid, trihydroxybenzene.

Description: Shiny white crystals that turn gray on exposure to air and light. Sinks and dissolves. The water solution darkens on exposure to air, quite rapidly if the solution is alkaline.

Toxicity:

Local - Irritant.
Systemic - Moderate.
Aquatic - High.

Detection. Detect as GALLIC ACID (see that entry for method) or as PYROCATECHOL (osmium tetroxide method).

QUATERNARY AMMONIUM SALTS $(R^1)(R^2)N(R^3)(R^4)$

Includes: Cationic surfactants and detergents, benzalkonium detergents, quaternary amines, and alkyl aryl ammonium halides. There are dozens of brand names.

Description: A large family of commercially important detergents, surfactants, antiseptics, and fungicides. They include such typical substances as benzalkonium chloride. Generally colorless to yellowish amorphous solids; frequently commercially available in aqueous solution. Aromatic odor, very bitter taste. They sink and dissolve readily, and will probably make flowing water foam and suds. Alkaline to litmus.

Toxicity:

Local - Slightly irritating; can crack and dry skin. Avoid spattering into eyes.
Systemic - Moderate by ingestion.
Aquatic - Moderate.
Other - Can cause extensive foaming and sudsing.

Detection: Mix 1 ml of sample with 10 ml of bromophenol blue reagent. This reagent consists of 7% of 0.2N sodium acetate, 91% acetic acid, and 2% of 0.1% ethanolic bromophenol blue solution. Positive result: mixture turns sky blue. (1, 4).

QUINACRINE HYDROCHLORIDE $C_{23}H_{30}ClN_3O \cdot 2\,HCl$, tricyclic

Synonyms: The most common trade name for this antimalarial compound is Atabrine; there are at least a dozen other trade names.

Description: Bright yellow crystals that sink and dissolve in water, giving an extremely fluorescent solution that is bitter to the taste and acid to litmus.

Toxicity:

Human - Low.
Aquatic - High.

Detection: The brilliant fluorescence of this compound is detectable under UV light in dilutions of several parts per million (1, 4). May also be detected by tests for unsaturation (see BENZENE), and tests for secondary amines (see PYRIDINE).

QUINHYDRONE $C_6H_4(OH)_2 \cdot C_6H_4O_2$

Synonym: Green quinhydrone.

Description: The addition product of HYDROQUINONE and QUINONE. Green crystals with metallic sheen; reddish brown by transmitted light. Sinks; slightly soluble.

Toxicity:

Human - Moderate to high.
Aquatic - High.

Detection: Detect as QUINONE and HYDROQUINONE.

QUININE

$C_{20}H_{24}N_2O_2$, tetracyclic.

Includes: Quinidine and the common derivatives.

Synonyms: Trade names of this compound and its common derivatives run to several dozen.

Description: The pure substance is a bulky white amorphous powder or crystalline alkaloid. Odorless, very bitter. Sinks; slightly soluble. The more soluble derivatives include: the acid sulfate, hydrohalides, methiodide, tartrate, gluconate, sulfate, acetylsalicylate, arsenate, ascorbate, benzoate, bisulfate, dihydrohalides, lactate, ethyl sulfate, and hypophosphite. Quinine and its derivatives have a characteristic blue fluorescence in dilute sulfuric acid.

Toxicity:

Human - Low, except by ingestion (moderate).
Aquatic - Moderate.

Detection: The very bitter taste of quinine (familiar as quinine bitters and quinine tonic water) can be detected at a few ppm. (1, 5, 6).

Alternatively, mix 2 ml of sample with 1 ml of 2% eosin solution and 2 ml of 5:1 0.2M disodium phosphate and 0.1M citric acid. Positive result: solution turns red. (2, 5, 6).

QUINOLINE C_9H_7N, bicyclic

Synonyms: Benzazine, benzopyridine, chinoleine, leucoline.

Description: Refractive, colorless, hygroscopic liquid that darkens with age, light, and moisture. Sharp odor. Like pyridine. Just sinks; may float on salt or brackish water. Slowly dissolves.

Toxicity:

Human - Moderate.
Aquatic - Moderate to high.

Detection: Detect as secondary amine (see PYRIDINE) or as unsaturated organic (see BENZENE). In an improvised laboratory, UV spectrophotometry is the preferred method of identification.

QUINONE $C_6H_4O_2$

Synonyms: Benzoquinone, chinone, cyclohexadienedione.

Description: Yellow crystals. Penetrating odor like chlorine. Irritating vapors. Sinks; slightly soluble. Combustible.

Toxicity:

Local - Vapors and solutions are very irritating and can cause severe skin and eye damage.
Systemic - Moderate.
Aquatic - High.

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE.

Detection: Mix 2 ml of sample with 2 ml of aqueous saturated rhodamine solution and 2 ml of concentrated NH_4OH. Gently shake the mixture. Positive result: the para isomer turns the mixture green or blue, the ortho isomer turns it red to violet. (1, 4).

RESORCINOL $C_6H_4(OH)_2$

Synonyms: Benzenediol, dihydroxybenzene, hydroxyphenol, resorcin.

Description: White crystals that turn pink on exposure to light. Sweet taste. Sinks and dissolves. A common topical antiseptic.

Toxicity:

Local - Irritates skin in concentrations above 10%.
Systemic - Moderate by ingestion.
Aquatic - Moderate.

Detection: Add dilute ferric chloride to sample. Positive result: solution turns violet. GALLIC ACID, PYROGALLOL, PYROCATECHOL, and related compounds also give a color reaction with ferric chloride. (1, 4, 6).

SALICYLALDEHYDE $(OH)C_6H_4(CHO)$

Synonyms: Hydroxybenzaldehyde, salicylal, salicylic aldehyde.

Description: Colorless oily liquid or dark red oil (depending on purity and exposure). Bitter almond odor, burning taste. Sinks; slightly soluble. Combustible.

Toxicity:

Human - Low.
Aquatic - High for algae, low for fauna.

Detection:

(I). Detect as an aldehyde (see PENTANAL for methods).

(II). Mix 2 ml of sample with 2 ml of ethanol and 1 ml of 0.5M $Co(NO_3)_2$. Add 1 ml of 0.1% o-phenylenediamine in dilute acetic acid. Positive result: mixture turns orange-red. (1, 4).

SALICYLIC ACID $(HO)C_6H_4(COOH)$

Synonym: Hydroxybenzoic acid.

Description: White crystalline solid; gradually discolors in sunlight. Sinks; slightly soluble. Any trace of iron turns the acid and its salts red. The common alkali salts are soluble. A common keratolytic, antimicrobial, and fungicide.

Toxicity:

Local - May irritate skin of some people.
Systemic - Low.
Aquatic - Moderate.

Detection: Acidify the sample with HCl until just acid to litmus. Mix 2 ml of sample with 2 ml of 0.9% ferric chloride solution and 2 ml of 1:10 acetic acid. Positive result: mixture turns violet. (1, 4, 6). Note that many other hydroxybenzene structures give a color reaction with $FeCl_3$ (see GALLIC ACID, PYROCATECHOL, PYROGALLOL, RESORCINOL).

SELENIUM

Se

Includes: Selenium compounds.

Description: Elemental selenium exists in several forms: amorphous (dark red to black powder), crystalline (dark red), and metallic (gray to black crystals). Sinks; insoluble, but there are several colloidal forms. Many Se compounds are commercially important. They include selenic acid (very soluble), selenous acid (very soluble), sodium selenite (very soluble), the oxide (very soluble), the halides and oxyhalides (soluble or decomposed by water to soluble products); a few compounds are not soluble or only very slightly soluble (hexafluoride, dialkyldithiocarbamate, and sulfides).

Toxicity:

Local - Low, except for the fuming oxyhalides, which are corrosive poisons.
Systemic - High by inhalation, otherwise low.
Aquatic - Uncertain; there is some evidence that Se is a cumulative poison. Because Se attacks sulfhydryl enzymes, it is probably more toxic to animals than to plants.

Detection: Add 2 ml of concentrated sulfuric acid to 1 ml of sample; then add 0.5 g of $NaHSO_3$. Heat to boiling for 1 minute. Positive result: mixture turns red or a red precipitate form. Stannous ion interferes. (2, 5).

SILVER

Ag

Includes: Silver compounds.

Description: Silver and its compounds denature proteins, and are often used as antiseptics. Many are sensitive to light, and are widely used in photography and printing. Toxicity varies with solubility. Of the common compounds, the following are soluble: chlorate and perchlorate, fluoride, hyponitrite, lactate, nitrate (lunar caustic), permanganate, picrate, and selenate. The following have limited solubility: acetate, bromate, chlorite, chromate and dichromate, iodate, nitrite, and sulfate. The following are practically insoluble: arsenate, bromide, carbonate, chloride, cyanide, iodide, oxalate, oxide, phosphate, and sulfide. Many common natural conditions will lead to the precipitation of silver from solution, since the carbonate, chloride, phosphate, oxide, and sulfide are practically insoluble. The insoluble forms are mostly off-white, gray, or black. At suspected spill sites, it is important to collect samples of bottom sediments and milky or grayish suspensoids, which may be dissolved in nitric acid and then tested for the silver ion by the methods given below.

Toxicity: (N. B. Varies with solubility).
Local - Caustic if very soluble; irritant otherwise.
Systemic - The nitrate is a corrosive poison; otherwise, low to moderate.
Aquatic - High.

Detection: Use 2 test tubes. To each add 3 ml of 0.25% $(NH_4)_2Ce(NO_3)_6$ in 1% HNO_3 and 2 ml of dilute HCl. To one tube, add 1 ml of reagent; to the other, add 1 ml of water. Positive result: sample decolorizes the yellow ceric ammonium nitrate solution more rapidly than the water. Mn, ferrous, and stannous ions interfere. (1, 4).

SLUDGE, CHEMICAL (from water supply treatment)

Description: There are two types of "chemical" sludge from treatment of water supplies. One is largely organic, and results from the coagulation and precipitation of suspended matter with the aid of aluminum or iron compounds which enhance flocculation. The other is largely inorganic, and results from water softening processes; it is principally calcium and magnesium compounds.

A third type of sludge from water treatment is organic. It results from the backwashing of filters, and is essentially similar to the suspended microbiota in the water body from which the supply was drawn. It is an organic slime

Toxicity: Aquatic only - The aluminum or iron from coagulants may be mobilized by chemical or biological action and develop a moderate toxicity to the aquatic biota. The calcium and magnesium from softening are not a toxic hazard but may damage bottom life by sedimentation, or gill and filter membrane by blanketing. Organic sludges also threaten oxygen depletion through increased BOD.

Detection: For aluminum and iron, see ALUMINUM SULFATE and FERRIC HYDROXIDE.

For softening products, test for calcium; see CALCIUM CARBIDE

For organic material, depleted oxygen or increased BOD.

SLUDGE, DIGESTED SEWAGE

Description: Heavy, brown, often malodorous, fairly homogeneous slurry that is rich in organic matter and microbial metabolites.

Toxicity: See SLUDGE, RAW UNDIGESTED SEWAGE. Comments are generally applicable here. The hazard of human infection is diminished.

Detection: As for raw sludge, high BOD is the main indicator. If the waters are naturally clear, turbidity will be seen if there has been a heavy discharge.

SLUDGE, RAW UNDIGESTED SEWAGE

Description: Heavy brown slurry, carrying garbage, excreta, and other "sanitary" wastes. There are two principal hazards: the immediate threat from microbial pathogens, and a longer-term effect of increased BOD. Spills may occur from land or water borne vehicles, or from pipelines and lagoons.

Toxicity: The infective hazard is likely to be more than from whole sewage, because bacteria and viruses are effectively precipitated with the sediment and remain viable.

Chemical contaminants are similarly concentrated. Adsorbed pesticides may become desorbed. Boron has been shown to adsorb on sludges. Ammonia and other nutrients may be high, and also soluble sulfides.

Detection: Organic components by BOD. Chemical components by appropriate test based on other evidence as to probable presence. Bacteria and viruses cannot be detected rapidly in the field.

SODIUM Na

Synonym: Natrium.

Description: Soft, silvery metal that reacts violently with water to form SODIUM HYDROXIDE and hydrogen. Metallic sodium is stored and shipped in air-tight containers or immersed in naphtha. Severe fire risk in contact with water.

Toxicity:

Local - The metal causes severe skin burns.
Systemic and Aquatic - See SODIUM HYDROXIDE.

Detection: Use pH indicator or meter to test for strong base. Tests for the sodium ion are of limited value because sodium is normal constituent of most water, usually the most prevalent metallic one. A simple test is as follows. Neutralize the samples with 3N HCl. To 2 ml of the neutralized sample, add 8 ml of zinc uranyl acetate reagent. Positive result: yellow precipitate. (2, 5, 6).

SODIUM ARSENATE

Na_3AsO_4 and Na_2HAsO_4

Synonyms: Trisodium arsenate, dibasic sodium arsenate, disodium arsenate.

Description: Clear, colorless crystals. Mild alkaline taste. Very soluble. The water solution is alkaline to litmus.

Toxicity:

Human - High.

Aquatic - High. It has been reported that some fish can tolerate concentrations of 2000 ppm for 3 hours.

Detection: Tests for Na are of limited utility; see SODIUM. The AsO_4 is the toxic component; see LEAD ARSENATE for methods.

SODIUM AZIDE NaN_3

Synonyms: None common.

Description: Colorless crystals that sink and dissolve. On heating, it decomposes into sodium and nitrogen.

Toxicity:

Human - High by ingestion, otherwise low.
Aquatic - High.

Detection: Mix 2 ml of sample with 2 ml of ammonium sulfide solution and 2 ml of 0.1N iodine solution. Positive result: immediate evolution of bubbles of nitrogen. (1, 5). This test cannot begin to detect sodium azide in toxic concentrations; it is only useful where the concentration is well above the ppm range.

SODIUM BISULFITE $NaHSO_3$ and $Na_2S_2O_5$

N. B. The sodium bisulfite of commerce is chiefly the metabisulfite, $Na_2S_2O_5$.

Synonyms: Sodium acid sulfite, sodium metabisulfite, sodium hydrogen sulfite.

Description: White, crystalline solid. Sulfurous odor and taste. Unstable in air, gradually oxidized to the sulfate. Sinks and dissolves. The solution is acid.

Toxicity:

Local - Concentrated solutions may irritate skin.
Systemic - Low.
Aquatic - Moderate to low.
Other - Look for bleaching effects.

Detection: Tests for Na are of limited utility; see SODIUM. Test for bisulfite as follows. Use 2 test tubes. To each add 1 ml of sample. To tube A, add 1 ml of 5% formaldehyde. Then add 1 ml of 0.1N iodine solution to both. Positive result: iodine is decolorized in tube B, but is not decolorized in tube A. (1, 4, 6).

Commercial kits are available for detecting sulfites (including bisulfites); suppliers include Lamotte, Taylor, Hellige, and Hach. Sensitivity range is 2-300 ppm. (1, 4, 6).

SODIUM CHROMATE

Na_2CrO_4

Synonym: Neutral sodium chromate.

Description: Yellow, somewhat deliquescent crystals that sink and dissolve, giving an alkaline solution.

Toxicity:

Local - Irritant; corrosive in high concentration.
Systemic - Moderate by ingestion; low by skin absorption.
Aquatic - High to moderate.

Detection: Tests for Na are of limited utility; see SODIUM.

See AMMONIUM CHROMATE for chromate tests.

SODIUM CYANATE $NaOCN$

Synonyms: None common.

Description: White crystalline solid that sinks and dissolves. The cyanate ion is slowly converted to cyanide; see BARIUM CYANIDE, POTASSIUM CYANIDE, and HYDROCYANIC ACID.

Toxicity:

Human - Low, except by ingestion.
Aquatic - Moderate and persistent.

Detection: Sodium tests are of limited utility; see SODIUM. Test for cyanate as follows. Mix 2 ml of sample with 1 ml of cupric nitrate solution and 1 ml of 0.8% aqueous pyridine solution. Positive result: mixture turns red. (1, 5, 6).

SODIUM CYANIDE

NaCN

Synonym: Cyanogran.

Description: White crystalline solid. Odorless when dry; when damp, emits slight odor of HYDROCYANIC ACID. Freely soluble. The aqueous solution is strongly alkaline and rapidly decomposes, forming a toxic layer of hydrogen cyanide at the water surface. Once widely used in pesticides, but now widely replaced by POTASSIUM CYANIDE.

Toxicity:

Human - High and fast-acting by ingestion and inhalation of hydrogen cyanide vapors. Risk of absorption through injured skin.

Aquatic - High.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Na tests are of limited utility; see SODIUM.

See BARIUM CYANIDE and HYDROCYANIC ACID for CN tests.

SODIUM DICHROMATE $Na_2Cr_2O_7$

Synonyms: Sodium bichromate, bichromate of soda.

Description: Bright scarlet crystalline solid. Very soluble. The solution is acidic.

Toxicity:

Local - Irritant and caustic.
Systemic - Moderate by ingestion, low otherwise.
Aquatic - Moderate.

Detection: Na tests are of limited utility; see SODIUM.

See AMMONIUM DICHROMATE for dichromate tests.

SODIUM FERRICYANIDE $Na_3Fe(CN)_6$

Synonyms: Red prussiate of soda, sodium hexacyanoferrate (III).

Description: Ruby red deliquescent crystals that sink and dissolve. Exposure slowly liberates hydrogen cyanide.

Toxicity:

Human - Low.
Aquatic - Reports vary widely, sometimes High.

Detection: Na tests are of limited utility; see SODIUM.

See AMMONIUM FERRICYANIDE for ferricyanide tests.

SODIUM FERROCYANIDE $Na_4Fe(CN)_6$

Synonyms: Sodium hexacyanoferrate (II), sodium prussiate yellow, yellow prussiate of soda.

Description: Pale yellow, semitransparent, crystalline solid. Exposure to sunlight and strong acids over time liberates hydrogen cyanide.

Toxicity: See SODIUM FERRICYANIDE.

Detection: Na tests are of limited utility; see SODIUM.

See AMMONIUM FERROCYANIDE for ferrocyanide tests.

SODIUM FLUORIDE NaF

Synonyms: Florocid, Flura-Drops, Karidium, Villiaumite, Zymafluor.

Description: Clear, shiny, crystalline powder. Insecticide grades are often tinted blue. Household insecticide grades must be tinted Nile blue. Sinks and dissolves. The water solution is mildly alkaline, and reacts with silicates.

Toxicity:

Local - Concentrated solutions are irritant.
Systemic - Moderate to high.
Aquatic - Moderate to high.

Detection: Na tests are of limited utility; see SODIUM.

See ALUMINUM FLUORIDE for F tests.

SODIUM FLUOSILICATE Na_2SiF_6

Synonyms: Sodium fluorosilicate, sodium silicofluoride.

Description: Tasteless, odorless, white crystalline solid. Sinks and dissolves.

Toxicity:

Local - Irritant

Systemic - Moderate by ingestion and inhalation.

Aquatic - Moderate.

Detection: Na tests are of limited utility; see SODIUM. Test for fluosilicate as follows. Mix the sample with 3M NaOH. A gelatinous precipitate occurs if fluosilicate is present.

SODIUM HYDROSULFIDE $NaHS$

Synonyms: Sodium bisulfide, sodium sulfhydrate, sodium hydrogen sulfide.

Description: Colorless to lemon-colored crystalline solid. Very hygroscopic. Readily hydrolyzed in moist air to SODIUM HYDROXIDE and SODIUM SULFIDE. Sinks and dissolves. Weakly alkaline. Hydrogen sulfide slowly liberated in the presence of water and carbon dioxide, giving the characteristic odor of rotten eggs.

Toxicity:

Local - Irritant.
Systemic - Low.
Aquatic - High to moderate.
Other - Very oxygen-demanding; may drastically reduce DO. Look for discoloration on rocks and structures. May taint the flavor of fish.

Detection: Na tests are of limited utility; see SODIUM. To test for hydrosulfide, mix the sample with 3M $NaOH$. Then test for sulfide ion (see AMMONIUM SULFIDE for method).

SODIUM HYDROXIDE NaOH

Synonyms: Caustic soda, lye, sodium hydrate, white caustic.

Description: Deliquescent, white, very corrosive solid.
Absorbs water and CO_2 from air. Sinks; very soluble.
A powerful alkali base. Aqueous solutions feel oily.

Toxicity:
Local - Powerfully caustic; burns and irritates tissues.
Systemic - A corrosive poison, moderately toxic by ingestion.
Aquatic - High to moderate.
Other - Look for corrosion effects.

WEAR PROTECTIVE CLOTHING.

Detection: Use pH indicator to test for strong base. (1, 3).
Na tests are of limited utility; see SODIUM.

SODIUM METHYLATE H_3CONa

Synonym: Sodium methoxide.

Description: Flowing white powder. Sensitive to oxygen. Decomposed by water to METHANOL and SODIUM HYDROXIDE.

Toxicity: See METHANOL and SODIUM HYDROXIDE.

Detection: See METHANOL and SODIUM HYDROXIDE.

SODIUM NITRITE $NaNO_2$

Synonyms: Diazotizing salts, erinitrit.

Description: White to yellowish hygroscopic solid. Very slowly oxidizes in air to sodium nitrate. Sinks and dissolves easily. Decomposed by even weak acids to evolve fuming nitrous anhydride. The aqueous solution is weakly alkaline.

Toxicity:

Human - Moderate.
Aquatic - Moderate to high.

Detection: Na tests are of limited utility; see SODIUM. To detect nitrite, mix 2 ml of sample with 2 ml of 0.6% sulfanilic acid in 20% HCl. Let stand 5 minutes. Then add 2 ml of 0.6% alpha-naphthylamine HCl in 1% HCl. Positive result: solution turns reddish purple. (2, 5, 6).

SODIUM OLEATE $C_{17}H_{33}COONa$

Synonyms: Oleic acid sodium salt, Eunatrol.

Description: White powder; slight odor of tallow. Dissolves in water, giving a mildly alkaline solution. A component of many kinds of soap. Combustible.

Toxicity:

Human - Low.
Aquatic - Moderate to high.
Other - Foams and suds; may cause a "bathtub ring" precipitate in hard water.

Detection: Add a few drops of methyl orange indicator to 10 ml of sample; then acidify with 1:1 sulfuric acid. Extract this solution with 1:1 petroleum ether and ethyl ether. Evaporate the solvent on a steam bath, then test the residue for OLEIC ACID (see that entry for method). (1, 4).

Alternatively, high concentrations of any fatty acid or soap may be detected as follows. (1) Acidify 5-10 ml of sample with 1:1 sulfuric acid. Fatty acids will rise to the surface as an oily slick. (2) Prepare reagent as follows: Add a few drops of Nile blue sulfate to 5 ml of dilute sulfuric acid and boil for 5 minutes. (3) Add a few drops of the reagent to the oil-slick mixture; stir well and let stand a few minutes. Positive result: fats and fatty acids will preferentially absorb the dye; fats will be stained red, and fatty acids will be stained blue. (1, 4).

SODIUM PALMITATE $H_3C(CH_2)_{14}COONa$

Synonyms: Sodium cetylate, sodium hexadecanoate, sodium hexadecylate.

Description: A characteristic household soap (bath, toilet, and laundry). A white solid available in many commercial forms (cakes, flakes, powders, etc.).

Toxicity:

Human - Low.
Aquatic - Moderate to high.
Other - Foams and suds; may cause "bathtub ring" precipitate in hard water.

Detection: There is no suitable method for detection of low concentrations at water's edge. In an improvised laboratory, identification may be performed as follows. Add a few drops of methyl orange indicator to 10 ml of sample and acidify with 1:1 sulfuric acid. Extract the solution with 10 ml of 1:1 petroleum ether and ethyl ether. Evaporate the solvent on a steam bath. Then transfer the residue to a round-bottomed flask. Add to the flask 5 ml of 12% BF_3 in methanol and reflux on a steam bath for 2 minutes. Let cool. Then extract with 10 ml of *n*-pentane. Analyze the methyl palmitate formed by GC. (1, 4, 6).

High concentrations may be detected using the alternative method given for SODIUM OLEATE.

SODIUM PHOSPHATE

Na_3PO_4, Na_2HPO_4, NaH_2PO_4,
$Na_4P_2O_7$, $Na_2H_2P_2O_7$

Synonyms: All the common forms are included: tribasic (tert), dibasic (sec), monobasic (prim) sodium phosphate, as well as normal (tetra) sodium pyrophosphate (TSSP) and acid (disodium) sodium phosphate (TASP).

Description: All are white crystalline solids that dissolve readily. Na_3PO_4 is very alkaline, NaH_2PO_4 is acid; the others are slightly alkaline.

Toxicity:

Human - Low.
Aquatic - Moderate to low, depending on the form. Na_3PO_4 is the most toxic, $Na_4P_2O_7$ the least toxic.
Other - Phosphate is a plant nutrient that may stimulate plant and algal growth.

Detection: Na tests are of limited utility; see SODIUM.

See AMMONIUM PHOSPHATE for phosphate tests.

SODIUM SILICATE

Varies from $Na_2O \cdot 3.75\ SiO_2$

to $2\ Na_2O \cdot SiO_2$

Synonym: **Water glass.**

Description: Depending on the composition, lumps of greenish glass or white powders (solubility varies) or liquids varying from clear and flowing to cloudy and viscous. Forms gels with acids over a wide pH range (1-9). It is coagulated by brine and precipitated by alkaline earth and heavy metal ions. Many forms are strongly alkaline in solution.

Toxicity:

Human - Low.
Aquatic - Low.
Other - Fouling of shores and surfaces with lumps and gels.

Detection: Na tests are of limited utility, see SODIUM. Detect silicate as follows. Acidify the sample with 3M HCl; a gelatinous precipitate indicates that the silicate ion may be in the sample. (1, 5, 6).

SODIUM STEARATE

$C_{17}H_{35}COONa$

Synonyms: Sodium octadecanoate, stearic acid sodium salt.

Description: White powder; fatty odor; soapy feel. Sinks and slowly dissolves, forming an alkaline solution. A soap often used in toothpastes and cosmetic preparations.

Toxicity:

Human - Low.
Aquatic - Moderate to high.
Other - Foams and suds; may cause a "bathtub ring" precipitate in hard water.

Detection: Na tests are of limited utility; see SODIUM. Detect palmitate as a soap; see SODIUM OLEATE and SODIUM PALMITATE for methods.

SODIUM SULFIDE

Na_2S

Synonyms: Sodium monosulfide, sodium sulfuret.

Description: Yellowish crystalline solid that discolors on exposure to air, turning brick red and finally black. Commercially available as crystals, lumps, and flakes. Rotten-egg odor of hydrogen sulfide. Sinks and dissolves freely, giving a strongly alkaline solution that liberates hydrogen sulfide as it is exposed to carbon dioxide and acids.

Toxicity:

Local - Irritant; do not handle with bare hands.
Systemic - Low; vapor hazard from hydrogen sulfide.
Aquatic - Varies from high to low.
Other - Very oxygen-demand; may drastically reduce DO. Look for discoloration on rocks and structures. May taint the flavor of fish.

Detection: Na tests are of limited utility; see SODIUM.

See AMMONIUM SULFIDE for sulfide methods.

SODIUM SULFITE Na_2SO_3

Synonyms: None common.

Description: White crystals or powder. Saline, sulfurous taste. Sinks and dissolves, forming a slightly alkaline solution. A widely used bleaching agent and preservative, a reducing agent and a substitute for "Hypo" in phtography.

Toxicity:

Human - Low.
Aquatic - Moderate to low.
Other - Look for bleaching effect, especially on plants.

Detection: Na tests are of limited utility; see SODIUM.

See FERROUS SULFITE for sulfite methods.

SODIUM THIOCYANATE NaSCN

Synonyms: Sodium sulfocyanate, sodium rhodanide, sodium rhodanate, sodium sulfocyanide.

Description: Colorless or white deliquescent crystals. Sink and dissolve, lowering water temperature considerably.

Toxicity:

Human - Low (the cyanide effect is not involved).
Aquatic - Moderate.

Detection: Na tests are of limited utility, see SODIUM.

See AMMONIUM THIOCYANATE for thiocyanate methods.

SODIUM TUNGSTATE Na_2WO_4

Synonym: Sodium wolframate.

Description: Colorless crystals or white crystalline powder that sinks and dissolves. The solution is slightly alkaline.

Toxicity:

Human - Low.
Aquatic - Moderate.

Detection: Na tests are of limited utility; see SODIUM. Test for tungstate as follows. Mix 2 ml of samples with 1 ml of concentrated HCl and 1 ml of 10% KSCN solution. Add to it 2 ml of freshly prepared 20% $SnCl_2$ in concentrated HCl. Positive result: solution turns bluish-green. Fluoride and selenium interfere. (1, 5, 6).

SORBITOL $CH_2OH(HCOH)_4CH_2OH$

Synonyms: Glucitol, gulitol, hexahydric alcohol, sorbit, and a variety of proprietary trade names.

Description: Colorless crystalline solid. Hygroscopic and combustible. Odorless; sweet taste. Sinks and dissolves freely; concentrated solutions are syrupy. Widely used as sweetening agent, humectant, pharmaceutical vehicle, and antifreeze.

Toxicity:

Human and Aquatic - Practically none.
Other - Raises BOD.

Detection: Detect as a glycol; see ETHYLENE GLYCOL for method.

STANNOUS CHLORIDE $SnCl_2$

Synonyms: Tin dichloride, tin protochloride, tin crystals, tin salt.

Description: White crystalline mass or flakes, fatty appearance. A powerful reducing agent. It absorbs oxygen from the air to form an insoluble oxychloride. It dissolves in water, but in great dilution it forms an insoluble basic salt.

Toxicity:

Local - Irritant to skin and mucous membranes
Systemic - Low
Aquatic - High

Detection: It is important to collect bottom samples and filter samples from cloudy waters because $SnCl_2$ is converted by natural processes into insoluble products when exposed to water and air. Boil suspect samples in aqua regia to redissolve the tin, then proceed as follows.

(I). Mix the sample with 0.1N ammonium sulfide. Positive result: brown precipitate. (1,4).

(II). Mix the sample with 0.1N mercuric chloride. Positive result: white to gray precipitate. (1,4).

See AMMONIUM CHLORIDE for Cl tests; they are of limited utility compared to Sn tests for this compound.

STRONTIUM CHLORIDE $SrCl_2$

Synonyms: None.

Description: Odorless, white, crystalline solid, deliquescent in moist air. Sharp, bitter taste. Sinks and dissolves readily. However, when exposed to CO_2, the nearly insoluble white carbonate is formed.

Toxicity:

Human - Low.
Aquatic - Moderate.

Detection: It is important to collect bottom samples and filter samples from cloudy waters because the Sr ion is precipitated as the insoluble white carbonate in the presence of carbon dioxide. Boil suspect samples in aqua regia, to redissolve the Sr, then proceed as follows. Add several drops of saturated K_2CrO_4 to 2 ml of sample. Let stand for one minute. Then add 1 ml of 0.2% rhodizonate solution (which must be fresh). Positive result: solution turns reddish brown. (1, 5).

See **AMMONIUM CHLORIDE** for Cl tests; they are of limited utility compared to the Sr tests for this compound.

STRONTIUM NITRATE $Sr(NO_3)_2$

Synonyms: None.

Description: White crystalline solid. Sinks and dissolves readily. Strong oxidizing agent. When the water solution is exposed to CO_2, the nearly insoluble white carbonate is formed.

Toxicity:

Human - Low.
Aquatic - Moderate to low.

Detection: See STRONTIUM CHLORIDE for Sr methods.

See AMMONIUM NITRATE for nitrate tests; they are of limited value compared to the Sr tests for this compound.

STYRENE

$C_6H_5(CH:CH_2)$

Synonyms: Cinnamene, cinnamol, phenylethylene, styrol, styrolene.

Description: Clear, colorless, very refractive, combustible oily liquid. Sharp aromatic odor. Floats; sparingly soluble. On exposure to heat and light, it slowly polymerizes and is oxidized. Polystyrene is a clear solid plastic, slightly heavier than pure water and insoluble in it.

Toxicity:

Local - Liquid and vapor irritant.
Systemic - Low.
Aquatic - Moderate.
Other - Fouling of surfaces by polystyrene.

Detection: Detect as an unsaturated compound; see BENZENE for methods.

SULFUR CHLORIDE S_2Cl_2

Synonyms: Disulfur dichloride, sulfur monochloride, sulfur subchloride.

Description: Amber to yellowish-red, oily, fuming liquid. Sharp, penetrating odor. Decomposes on contact with water to give HYDROCHLORIC ACID, SULFUR DIOXIDE, SULFUROUS ACID, hydrogen sulfide, thiosulfate, and other acid products.

Toxicity:

Local - Extremely corrosive and irritating.
Systemic - A corrosive poison. Moderate.
Aquatic - Moderate.
Other - Look for corrosion effects.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Detect as sulfide, sulfite, chloride, etc. For methods, see AMMONIUM SULFIDE, FERROUS SULFITE, AMMONIUM CHLORIDE, HYDROCHLORIC ACID, SULFUR DIOXIDE, SULFUROUS ACID. In addition, test for thiosulfate as follows. Mix 1 ml of sample with 1 ml of 3% NaN_3 and 1 ml of 0.1N iodine solution. Positive result: immediate evolution of gas bubbles (nitrogen). (1, 4).

SULFUR DIOXIDE SO_2

Synonyms: Sulfurous anhydride, sulfurous oxide.

Description: Colorless, nonflammable gas. Strong suffocating odor. Commercial form is liquefied gas. In water, the gas is in equilibrium with its formed acid (SULFUROUS ACID), which is a corrosive acid and a strong bleaching agent. Under the action of sunlight, it is gradually oxidized to SULFURIC ACID.

Toxicity:

Local - Very irritant liquid and vapor.
Systemic - High by inhalation; otherwise moderate.
Aquatic - (Moderate), a corrosive poison.
Other - Look for corrosion damage to plants, shoreline, and structures.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: The strong odor and the acid pH can be used to follow the spill in moderate concentration. For detecting the dilute acid and gas, commercial kits are available; sensitivity range is 1-400 ppm. Suppliers include Kitagawa, MSA, and Scott/Davis. (1 or 2, 5, 6).

SULFURIC ACID H_2SO_4

Synonyms: Hydrogen sulfate, oleum, spent sulfuric acid, oil of vitriol, buttery acid.

Description: Strongly corrosive, dense, oily liquid. Colorless to dark brown, depending on purity. Miscible with water in all proportions. The concentrated acid reacts violently with water. Reacts strongly with metals and many organic compounds. Some grades are fuming and hygroscopic. The fuming, concentrated grade is commonly called "oleum" on shipping labels.

Toxicity:

Local - Extremely irritating vapor; liquid causes severe burns.
Systemic - A corrosive poison; moderate.
Aquatic - Moderate.
Other - Look for corrosion effects on shorelines and structures.

Detection: Use pH indicator to detect acidity. Then test for sulfate ion (see ALUMINUM SULFATE for methods).

SULFUROUS ACID H_2SO_3

Synonym: Sulfur dioxide solution.

Description: A solution of about 6% SULFUR DIOXIDE in water. Clear, colorless liquid that gives off the sharp, suffocating odor of SULFUR DIOXIDE. Corrosive and bleaching agent. Gradually oxidizes to SULFURIC ACID.

Toxicity: See SULFUR DIOXIDE.

Detection: See SULFUR DIOXIDE.

SUPERPHOSPHATE

A mixture of calcium phosphates, calcium sulfate, iron oxide, silica, etc.

Includes: Triple superphosphate.

Description: The most important phosphorus fertilizer. White to grayish powders or granules. Sinks; solubility varies with the composition of the mixture, but usually slightly soluble.

Toxicity:

Human - Low.

Aquatic - Varies with solubility; usually low.

Other - Superphosphate is a fertilizer, and may stimulate the growth of algae and noxious plants.

Detection: See AMMONIUM PHOSPHATE for phosphate tests. Ca tests are of limited utility.

TANNIC ACID

Variable structure, depending
on origin; one important variety
is empirically $C_{76}H_{52}O_{46}$

Synonyms: Tannin, gallotannin, gallotannic acid, corilagin,
nutgall extract.

Description: Yellowish to light brown amorphous, bulky powder
or flakes or spongy masses. Faint characteristic
odor like tanned leather. Gradually darkens on exposure to air and light. Solub: very soluble.

Toxicity:

Local - May dry and discolor skin.
Systemic - Low.
Aquatic - High.
Other - Discoloration of structures.

Detection: Boil a mixture of 0.25% g of sodium tungstate,
0.02 g arsenious oxide, and 2 ml of 2N HCl. Add
to this mixture 2 ml of sample and 2 ml of 20%
sodium carbonate solution. Positive result: solution
turns blue. (1,5)

TETRAETHYLENE PENTAMINE $H_2N(C_2H_4NH)_3C_2H_4NH_2$

Synonym: TEPA.

Description: Viscous, hygroscopic liquid. Amine odor. Floats and dissolves. Combustible.

Toxicity:

Local: Irritant.
Systemic: Moderate.
Aquatic: (Moderate).

Detection: Detect as a primary amine and a secondary amine (see DIAMYLAMINE, PROPYLAMINE, and PYRIDINE for methods).

THALLIUM

Tl

Includes: Common thallium compounds.

Description: Thallium is a bluish white, soft metal that forms a skin of oxide in air. The metal and all of its most important compounds are poisonous, and are widely used in pesticides, as well as in many industries (metallurgy, electronics, optics, pyrotechnics). The soluble compounds are white to yellow crystals. The relatively insoluble forms include the halides (white to yellowish crystals), the sesquioxide, the sulfide, and the selenide (all dark crystals or powders). In contrast to many heavy metals, both the hydroxide and the carbonate are quite soluble, and except for the sulfide and the high-valence oxide, all the usual derivatives that might be formed after a spill in water are at least slightly soluble.

Toxicity:

Human - High.
Aquatic (High).

Detection: Treat suspect solids with 1M sulfuric acid to dissolve the Tl. Use the following test for the Tl ion. Mix 2 ml of sample with 2 ml of 10% KI. After a white precipitate forms, add 3 ml of 2% $Na_2S_2O_3$. Positive result: the white precipitate turns yellow. Pb and Ag interfere. (1, 5).

THIOGLYCOLIC ACID $HSCH_2COOH$

Synonyms: Mercaptoacetic acid, thioglycollic acid.

Description: Colorless liquid. Strong, unpleasant odor. Miscible with water. Readily oxidized by air to hydrogen sulfide and ACETIC ACID.

Toxicity:

Local - Irritant; can severely burn and blister skin.
Systemic - Moderate.
Aquatic - (Moderate).

Detection: The odors of hydrogen sulfide and acetic acid, and a somewhat acid pH can be used to detect fairly high concentrations. Also see ACETIC ACID; to detect sulfide, see AMMONIUM SULFIDE.

Test for the thioglycolate moiety as follows. Mix 2 ml of sample with 2 ml of 8% sodium acetate solution and 1 ml of 1% acetic acid. Add 1 ml of 37% formaldehyde solution, and set aside for 2 minutes. Then add 2 ml of phosphotungstic acid reagent (10 g of sodium tungstate in 80 ml of 10% phosphoric acid). Positive result: solution turns blue. Mercaptans interfere. (1,3).

THORIUM CHLORIDE $ThCl_4$

Synonym: Thorium tetrachloride.

Description: Colorless to light yellow crystalline solid. Hygroscopic; partially volatile. Sinks and dissolves.

Toxicity:

Local - Irritates mucous membranes.
Systemic - Moderate.
Aquatic - High.

Detection: Detect thorium in solution by mixing samples with a buffer solution (4.1% sodium acetate and 2.9% glacial acetic acid) that contains 0.02% carminic acid. Positive result: the solution turns yellow. Fe and Al interfere. (1, 5).

THORIUM NITRATE $Th(NO_3)_4$

Synonyms: None.

Description: White crystalline mass that sinks and dissolves freely, giving an acidic solution. A strong oxidizing agent.

Toxicity: See THORIUM CHLORIDE.

Detection: See THORIUM CHLORIDE for Th method.
See AMMONIUM NITRATE for NO_3 methods.

TITANIUM COMPOUNDS

Ti and its compounds

Includes: The elemental metal and its common compounds -- halides, hydride, isopropylate, oxalate, oxide, sulfate, and complex salts with ammonium and potassium; includes titanate, titanous, and titanyl compounds.

Description: Titanium metal is shiny, gray, and insoluble in water; it is widely used in metallurgy. Its halides, oxysulfate (titanyl sulfate, $TiOSO_4$) and isopropylate are unstable, and are decomposed on contact with moist air or water, often yielding highly irritating decomposition products. The alkali complexes are all water soluble. The sesquisulfate (titanous sulfate) and the commercially very important dioxide (Unitane, Titania) are insoluble, the powdered dioxide is widely used as a pigment for white paint, and the crystalline dioxide is used to make imitation diamonds. The oxide, oxysulfate, and tetrafluoride are white powders; the isopropylate and tetrachloride are unstable fuming liquids. Several of the salts give highly colored solutions (usually reddish purple), but these solutions are generally unstable, particularly when organic matter, oxygen, and other metals are present.

Toxicity:

Local - Dusts and decomposition products are irritants.
Systemic - Low, except the hydride, which is highly toxic.
Aquatic - High. Toxicity is lower in hard than in soft water.
Other - Unstable titanium compounds may cause corrosion damage.

Detection: Ti compounds often react with water to form insoluble precipitates; be certain to collect samples of suspect bottom solids and suspended solids. Both solids and liquids may be analyzed as follows. Evaporate the sample to dryness. Fuse the ashed solid with potassium pyrosulfate until effervescence ceases. Then dissolve the cooled mass in 10% H_2SO_4 by boiling. Positive reactions are: (1) hydrogen peroxide turns the solution yellow or orange; (2) morphine turns it red. (1, 4).

TOLUENE $(H_3C)C_6H_5$

Synonyms: Methylbenzene, phenylmethane, toluol.

Description: Colorless, refractive, flammable liquid.
Odor like benzene. Floats; very slightly soluble.

Toxicity:
Local - Liquid and vapor irritant.
Systemic - Moderate to low.
Aquatic - Moderate to high.

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE.

Detection: Commercial kits are available; sensitivity range is 1-1000 ppm. Suppliers include Kitagawa, MSA, and Scott/Davis. (1,4,6).

Alternatively, test for unsaturation (see BENZENE for method).

TOLUENE DIISOCYANATE $H_3CC_6H_3(NCO)_2$

Synonyms: Diisocyanatotoluene, tolylene diisocyanate, TDI, Nacconate.

Description: Colorless liquid at room temperature; freezes at about 70°F. Sharp, biting odor. Darkens on exposure to sunlight. Reacts with water to produce CO_2 and diaminotoluene (toluene diamine), which is a colorless liquid, miscible with water.

Toxicity:

Local : Very irritating vapor and liquid.
Systemic: Moderate by ingestion.
Aquatic : Moderate to high.

PROTECTIVE CLOTHING ADVISABLE.

Detection: Analyze for primary amine; see PROPYLAMINE for method.

TOLUIDINE $H_3CC_6H_4NH_2$

Synonyms: Aminotoluene, methylaniline.

Description: There are 3 isomers, all combustible and all slightly soluble. The *m* isomer is a colorless liquid that floats on water; *o* is a pale yellow liquid that turns red then brown in air and light, and may float or sink depending on temperature and dissolved solids; *p* is a shiny white solid (plates or leaflets) that sinks.

Toxicity:

Local - Irritant to skin and eyes.
Systemic - Moderate by ingestion, low by skin penetration.
Aquatic - Moderate.

PROTECTIVE CLOTHING ADVISABLE.

Detection: Analyze for primary amines; see PROPYLAMINE for method.

TRICHLOROPHENOL $HOC_6H_2Cl_3$

Synonyms: Collunosol, Dowicide 2 and 2S, Dowicide B, Trichlores.

Description: Colorless to yellowish or gray solid (depending on technical grade, isomer, or derivative). Strong phenolic odor. Sinks; almost insoluble. The sodium salt sinks and dissolves, giving a markedly alkaline solution. Used as bactericide, fungicide, and defoliant.

Toxicity:

Local - Strong irritant.
Systemic - Moderate to high by all routes.
Aquatic - High to fauna and flora.

WEAR RESPIRATOR AND PROTECTIVE CLOTHING.

Detection: Test for unsaturation (see BENZENE for method), for aromatic alcohol (see below), or for organic halide (see below). To test for aromatic alcohol, combine 2 ml of sample with 5 ml of reagent (a 10% solution of ceric ammonium nitrate in 2N HNO_3). Positive result: brown to greenish brown precipitate (1, 3). To test for organic halide, to 2 ml of sample add 5 ml of freshly prepared 15% NaI in acetone (Do Not Use If the Iodide Has Turned Reddish or Brown; it should be colorless). Positive result: reddish-brown precipitate. If test is not clear, put test solution in hot water (about 120°F) for 5-10 minutes; if no precipitate forms, test is negative. (1, 3).

TRIETHANOLAMINE $(HOCH_2CH_2)_3N$

Synonyms: TEA, trihydroxyethylamine.

Description: Colorless, viscous, hygroscopic liquid that jells at about 70°F. Turns brown on exposure to air and light. Slight ammoniacal odor. Sinks and dissolves, giving a strongly basic solution. Combustible. The article of commerce contains a large quantity of di- and monoethanolamine.

Toxicity:

Local - Irritant, especially to eyes.
Systemic - Low.
Aquatic - Moderate.

Detection: If the smell of ammonia is strong, test with pH indicator for a base. (1, 3). In any case, test for tertiary amine by mixing 2 ml of sample with 2 ml of 1% methyl iodide. Positive result: precipitate forms. (1, 4).

TRIETHYLAMINE $(C_2H_5)_3N$

Synonyms: None.

Description: Colorless liquid; strong ammoniacal odor. Floats; slightly soluble in warm water (above 65°F); miscible with cold water. Very flammable.

Toxicity:

Local - Strong irritant, especially to the eyes and lungs.
Systemic - Low.
Acute - Moderate.

Detection: Methods identical to TRIETHANOLAMINE. Commercial kits are also available; sensitivity range is 1-100 ppm. MSA is one supplier (I or 2,3,4).

TRIETHYLENETETRAMINE $H_2N(C_2H_4NH)_2C_2H_4NH_2$

Synonyms: TETA.

Description: Clear, yellowish, viscous, volatile liquid.
Slight ammoniacal odor. Floats; miscible.

Toxicity:
Local - Irritant liquid and vapor.
Systemic - Low.
Aquatic - Moderate to low.

Detection: Analyze for primary and secondary amine; see
DIAMYLAMINE and PROPYLAMINE for methods.

[illegible]ETHYLAMINE [illegible]

[illegible]

Description: The article of commerce may be either a compressed liquefied gas or an aqueous solution. [illegible]

[illegible]

[illegible]

VANADYL SULFATE $VOSO_4$

Synonyms: Vanadic sulfate, vanadium sulfate, vanadium oxysulfate.

Description: Blue crystalline powder or crystals. Sinks and dissolves.

Toxicity:

Human : Low.

Aquatic : Moderate to high.

Detection: Add 5% sulfuric acid to 5 ml of sample to acidify. Then add 1 ml of 10% phosphoric acid to 5 ml of acidified sample; this removes interference from iron. Finally, add a few ml of 3% hydrogen peroxide solution. Positive result: solution turns reddish-brown. Ti, V, possibly Mo.

VINYL ACETATE $CH_2CHOOCCH_3$

Synonyms: Acetoxyethylene, ethylene acetate.

Description: A raw material for polyvinyl resins. Colorless, clear, liquid; sweet, pleasant odor. Very flammable. Polymerizes in light to a clear, colorless glass. Inhibitors (chemical stabilizers) such as HYDROQUINONE and diphenylamine are usually added to prevent spontaneous polymerization. Both the liquid monomer and the solid polymer float, but the liquid is rather soluble, while the solid is insoluble.

Toxicity:

Local - Irritant, vapor harmful.
Systemic - Moderate; most toxic by inhalation.
Aquatic - Moderate.
Other - Loss due to fouling by the polymer.

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE.

Detection: Test for concentration, see BENZENE for method.

VINYL BROMIDE $H_2C:CHBr$

Synonyms: Bromoethylene, ethylene bromide.

Description: Very flammable colorless gas that liquefies at 60°F. Sinks; insoluble. The gas is heavier than air. Polymerizes to form a clear plastic solid.

Toxicity:

Local - Irritant liquid and vapor.
Systemic - Low.
Aquatic - (Low).
Other - Look for fouling by the polymer.

RESPIRATOR AND PROTECTIVE CLOTHING ADVISABLE.

Detection: Use two presumptive tests. Test for unsaturation (see BENZENE for method). Also test for organic halide (see TRICHLOROPHENOL for method).

VINYL CHLORIDE $H_2C:CHCl$

Synonyms: Chloroethene, chloroethylene, ethylene chloride, VC.

Description: The most important vinyl monomer. Colorless gas with sweet odor; usual commercial form is compressed, liquefied gas; the liquid is clear and colorless. Spontaneously polymerizes in the light; phenol often added to inhibit polymerization. Floats; slightly soluble; very flammable. The polyvinyl plastic is clear and insoluble; it floats.

Toxicity:

Local - Irritant liquid and vapor; the liquefied form is very cold, and may cause severe frostbite.
Systemic - Low.
Aquatic - Low.
Other - Fouling of shorelines and structures by polyvinyl.

PROTECTIVE CLOTHING AND RESPIRATOR ADVISABLE.

Detection: Commercial kits are available; sensitivity range is 100-2000 ppm. Suppliers include MSA, and Scott/Davis. (1,5,6).

XYLENE $C_6H_4(CH_3)_2$

Synonyms: Dimethylbenzene, methyltoluene, xylol

Description: There are three pure isomers (o-, m-, and p-) but the xylene of commerce is an isomeric mixture with the m-isomer predominating. Clear, colorless, mobile, flammable liquid. Aromatic odor, similar to benzene. Floats, practically insoluble.

Toxicity:

Human - Low to moderate, most likely by inhalation.
Aquatic - Moderate.

RESPIRATOR ADVISABLE.

Detection: Colorimetric detectors are available, measuring range is 10-1000 ppm. Suppliers include Kitagawa, MSA, and Auer-Dräger. (6,7,8)

Alternatively, test for unsaturation, see BENZENE for method.

XYLENOL

$HOC_6H_5(CH_3)_2$

Synonyms: Dimethylphenol, hydroxydimethylbenzene; a constituent of "cresylic acid", a commercial mixture of CRESOLS.

Description: There are several pure isomers, but the article of commerce is a mixture of isomers. White crystals. Coal tar odor. Sinks; slightly soluble. Combustible.

Toxicity:

Local - Irritant to skin.
Systemic - Moderate by ingestion, low by skin absorption.
Aquatic - Moderate.

Detection: Test for aromatic alcohol as follows. Combine 2 ml of sample with 5 ml of reagent (10% solution of ceric ammonium nitrate in 2N HNO_3). Positive result: brown to greenish-brown precipitate. (1, 3).

ZINC COMPOUNDS

Zn and its compounds

Includes: Elemental metallic zinc and all important zinc-containing compounds.

Description: Metallic zinc is a shiny, bluish metal that quickly forms a dull white skin of carbonate in air. With few exceptions, zinc compounds are white, sometimes tinged with yellow or gray. Yellow or orange zinc compounds include the chromate hydroxide, dichromate, selenide, and tannate; dark gray or purplish or brownish Zn compounds include the permanganate, phosphide, and telluride. Most of the common salts are soluble: halides and oxyhalides, nitrate, sulfate, acetate, formate, etc. Several others are slightly soluble: benzoate, caprylate, chromate hydroxide, citrate, fluoride, lactate, oxalate, and valerate. Several of the most important Zn compounds, however, are practically insoluble: carbonate and carbonate hydroxide, cyanide, ferrocyanide, oxide, phosphate, pyrophosphate, silicate, stearate, sulfide, and undecylenate. Zinc compounds are widely used in industry (refining, metallurgy, chemistry, textiles, electronics, wood products) and in medicine (deodorant, astringent, antiseptic, fungicide, and protectives in skin disease). Several organic Zn products are widely used in cosmetics, soaps, shampoos, toiletries, and patent medicines as bactericides and fungicides. Several important Zn compounds decompose under the action of water and air; these include the nitrite, permanganate, peroxide, phosphide, selenite, sulfide, sulfite, and telluride. It is of the utmost importance to remember that soluble Zn compounds may be converted to the insoluble carbonate, carbonate hydroxide, hydroxide, phosphate, pyrophosphate, silicate, or sulfide (which slowly oxidizes to the soluble sulfate) once they have been spilled in water.

Toxicity:

Local - Nonirritating except as follows: acetate, chloride, ethylsulfate, formate, permanganate, and sulfate.

Systemic - Low, except when the Zn is combined with such toxic components as arsenate, cyanide, phosphide, selenide, etc.

Aquatic - High, regardless of the presence of other toxic components. Much more toxic to fauna than to flora.

ZINC COMPOUNDS (continued)

Detection: Commercial kits are available for detection; sensitivity range is 0.1 - 10 ppm (1, 4, 6). Suppliers include Lamotte and Hach. There is also a presumptive test, which is interfered with by Cd, Sn (II), Pb, and As (III). Mix 1 ml of sample with 2 ml of 10% $Na_2S_2O_3$ and 1 ml of 2M NH_4CN and 5 ml of 0.002% dithizone in CCl_4. Positive result: the CCl_4 layer turns red. (1, 4, possibly 6).

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ZIRCONIUM SULFATE $Zr(SO_4)_2$ or $H_2ZrO(SO_4)_2$

Synonym: Disulfatozirconic acid.

Description: White, crystalline solid that sinks and dissolves. Water solutions are acid to litmus. At ordinary temperatures, dilute solutions deposit a solid on standing; this solid, known as Hauser's salt, is a rearrangement of the molecule with the addition of water. The more dilute the solution, the more rapid the deposition.

Toxicity:

Human - Low.
Aquatic - Moderate.

Detection: Treat suspect solids with boiling aqua regia to redissolve the Zr. Test for Zr ion as follows. Mix 2 ml of sample with 2 ml of concentrated HCl and 2 ml of aqueous 1% Alizarin solution. Positive result: red precipitate. (2, 5, 6).

APPENDIX B

CROSS INDEX
TO
APPENDIX A: DICTIONARY

There are two kinds of entry in this Cross Index:

1. A single name, in capital letters.
   Example: "ACETIC ACID."
   This means that there is a page in the Dictionary titled "ACETIC ACID". The pages are arranged alphabetically: the Introduction to the Dictionary explains the system.
2. Two names, separated by a colon; the second is in capital letters.
   Example: "Acetic acid amine: ACETAMIDE."
   This means that information about acetic acid amine is on the page titled "ACETAMIDE."

This Cross Index includes all the page titles of the Dictionary and all the synonyms.

ABIETIC ACID
ABS Detergents: ANIONIC SURFACTANTS
AC: ALLYL CHLORIDE
ACETALDEHYDE
ACETAMIDE
ACETANILIDE
ACETIC ACID
Acetic acid amine: ACETAMIDE
Acetic acid ammonium salt: AMMONIUM ACETATE
Acetic acid butyl ester: BUTYL ACETATE
Acetic aldehyde: ACETALDEHYDE
ACETIC ANHYDRIDE
Acetic oxide: ACETIC ANHYDRIDE
Acetoethylene: VINYL ACETATE
ACETONE CYANOHYDRIN
ACETONITRILE
ACETOPHENONE
Acetylbenzene: ACETOPHENONE
ACETYL BROMIDE
ACETYLENE
Acetylenogen: CALCIUM CARBIDE
Acetyl oxide: ACETIC ANHYDRIDE
Acid sodium phosphate: SODIUM PHOSPHATE
ACRIDINE
ACRYLIC ACID
Acrylic acid n-butyl ester: BUTYL ACRYLATE
Acrylic acid methyl ester: METHYL ACRYLATE
Acrylic resin monomer: METHYLMETHACRYLATE
ACRYLONITRILE
ADIPIC ACID
ADIPONITRILE
Adipyl dinitrile: ADIPONITRILE
Albone: HYDROGEN PEROXIDE
Aldehyde: ACETALDEHYDE
Aldehyde collidene: METHYLETHYL PYRIDINE
Aldehydine: METHYLETHYL PYRIDINE
Aldifen: DINITROPHENOL
Alkaryl sulfonates: ANIONIC SURFACTANTS
Alkyl aryl ammonium halides: QUATERNARY AMMONIUM SALTS
Alkyl benzene sulfonates: ANIONIC SURFACTANTS
Allomaleic acid: FUMARIC ACID
ALLYL ALCOHOL
ALLYL CHLORIDE
Aluminum borate: BORIC ACID
ALUMINUM FLUORIDE
ALUMINUM SULFATE
Aluminum trifluoride: ALUMINUM FLUORIDE
Alumogenite: ALUMINUM SULFATE
Amchlor: AMMONIUM CHLORIDE
Aminobenzene: ANILINE
Aminobutane: BUTYLAMINE
Aminoethane: ETHYLAMINE
Aminoethanol: MONOETHANOLAMINE
AMINO ETHYL ETHANOL AMINE
Aminomethane: METHYLAMINE
Aminonaphthalene: NAPHTHYLAMINE
Aminophen: ANILINE
Aminopropane: PROPYLAMINE
Aminopropanol: MONOISOPROPANOLAMINE
Aminotoluene: BENZYLAMINE and TOLUIDENE
AMMONIA
Ammonia, crystal: AMMONIUM CARBONATE
Ammonia gas: AMMONIA
Ammonia, household: AMMONIA
Ammonia, liquefied: AMMONIA
AMMONIUM ACETATE
Ammonium bichromate: AMMONIUM DICHROMATE
Ammonium bisulfide: AMMONIUM SULFIDE
Ammonium borate: BORIC ACID
Ammonium carbazotate: AMMONIUM PICRATE
AMMONIUM CARBONATE
AMMONIUM CHLORIDE
AMMONIUM CHROMATE
Ammonium chromate, neutral: AMMONIUM CHROMATE
AMMONIUM DICHROMATE
Ammonium disulfatonickelate: NICKEL AMMONIUM SULFATE
AMMONIUM FERRICYANIDE

AMMONIUM FERROCYANIDE
Ammonium hexacyanoferrate (III): **AMMONIUM FERRICYANIDE**
Ammonium hydrosulfide: **AMMONIUM SULFIDE**
Ammonium hydroxide: **AMMONIA**
Ammonium muriate: **AMMONIUM CHLORIDE**
Ammonium nickel sulfate: **NICKEL AMMONIUM SULFATE**
AMMONIUM NITRATE
AMMONIUM PICRATE
Ammonium picronitrate: **AMMONIUM PICRATE**
AMMONIUM PERCHLORATE
AMMONIUM PEROXYDISULFATE
Ammonium persulfate: **AMMONIUM PEROXYDISULFATE**
AMMONIUM PHOSPHATE
Ammonium phosphate, monobasic: **AMMONIUM PHOSPHATE**
Ammonium phosphate, primary: **AMMONIUM PHOSPHATE**
Ammonium phosphate, secondary: **AMMONIUM PHOSPHATE**
Ammonium rhodanide: **AMMONIUM THIOCYANATE**
Ammonium sesquicarbonate: **AMMONIUM CARBONATE**
AMMONIUM SULFATE
AMMONIUM SULFIDE
Ammonium sulfocyanate: **AMMONIUM THIOCYANATE**
Ammonium sulfocyanide: **AMMONIUM THIOCYANATE**
AMMONIUM THIOCYANATE
AMYL ACETATE
Amyl acetic ester: **AMYL ACETATE**
Amyl alcohol: **PENTANOL**
Amyl aldehyde: **PENTANAL**
Amyl carbinol: **HEXANOL**
Amylene: **PENTENE**
Amylene hydrate: **PENTANOL**
Amyl hydride: **PENTANE**
Anglesite: **LEAD SULFATE**
Anhydrous ammonia: **AMMONIA**
ANILINE
Anionic detergents: **ANIONIC SURFACTANTS**
Antifreeze: **ETHYLENE GLYCOL**
Antimonous chloride: **ANTIMONY TRICHLORIDE**
Antimonous fluoride: **ANTIMONY TRIFLUORIDE**
Antimony chloride: **ANTIMONY TRICHLORIDE**
Antimony compounds, soluble: **ANTIMONY POTASSIUM TARTRATE**
Antimony fluoride: **ANTIMONY TRIFLUORIDE**
Antimony oxide: **ANTIMONY TRIOXIDE**
ANTIMONY POTASSIUM TARTRATE
ANTIMONY TRICHLORIDE
ANTIMONY TRIFLUORIDE
ANTIMONY TRIOXIDE
Antimony white: **ANTIMONY TRIOXIDE**
AP: **AMMONIUM PERCHLORATE**
APC: **AMMONIUM PERCHLORATE**
Aqua fortis: **NITRIC ACID**
Aqua regia: **NITRIC ACID**
Artificial oil of ants: **FURFURAL**
Asphalt: **PETROLEUM PRODUCTS, HEAVY**
Atabrine: **QUINACRINE HYDROCHLORIDE**
Auro: **NEUTRAL SURFACTANTS**
Azaanthracene: **ACRIDINE**
Azacyclopropane: **ETHYLENEIMINE**
Aziridine: **ETHYLENEIMINE**
Azotic acid: **NITRIC ACID**

Banana oil: AMYL ACETATE
BARIUM CHLORIDE
Barium compounds, soluble: BARIUM CHLORIDE
BARIUM CYANIDE
Barium hydrate: BARIUM HYDROXIDE
BARIUM HYDROXIDE
BARIUM NITRATE
Battery acid: SULFURIC ACID
Benzalkonium chloride: QUATERNARY AMMONIUM SALTS
Benzalkonium detergents: QUATERNARY AMMONIUM SALTS
Benzazine: QUINOLINE
BENZENE
Benzene carbonyl chloride: BENZOYL CHLORIDE
Benzenecarboxylic acid: BENZOIC ACID
Benzenediol: HYDROQUINONE, PYROCATECOL & RESORCINOL
Benzenetriol: PYROGALLOL
Benzinoform: CARBON TETRACHLORIDE
Benzoate of soda: BENZOIC ACID
Benzoates: BENZOIC ACID
BENZOIC ACID
Benzol: BENZENE
BENZONITRILE
Benzopyridine: QUINOLINE
Benzopyrrole: INDOLE
Benzoquinone: QUINONE
BENZOYL CHLORIDE
BENZYLAMINE
BERYLLIUM SALTS
Bicarburetted hydrogen: ETHYLENE
Bichromate of soda: SODIUM DICHROMATE
Bis(chloroethyl)sulfide: MUSTARD GAS
Blackstrap: MOLASSES
Blue copperas: COPPER SULFATE
Blue stone: COPPER SULFATE
Blue vitriol: COPPER SULFATE
Boletic acid: FUMARIC ACID
Boracic acid: BORIC ACID
BORANES
Borates, soluble: BORIC ACID
Borax: BORIC ACID
BORIC ACID
Boron hydrides: BORANES
Bromoethylene: VINYL BROMIDE
BROMINE
Bromine cyanide: CYANOGEN BROMIDE
Butane: PETROLEUM PRODUCTS, LIGHT
Butanedicarboxylic acid: ADIPIC ACID
Butanediol: BUTYLENE GLYCOL
Butanethiol: BUTYL MERCAPTAN
Butanol: BUTYL ALCOHOL
Butenal: CROTONALDEHYDE
Trans-butenedioic acid: FUMARIC ACID
Butoxyethanol: ETHYLENE GLYCOL MONOBUTYL ETHER
Butter of antimony: ANTIMONY TRICHLORIDE
BUTYL ACETATE
BUTYL ACRYLATE
BUTYL ALCOHOL
BUTYLAMINE
Butyl cellosolve: ETHYLENE GLYCOL MONOBUTYL ETHER
BUTYLENE GLYCOL
Butyl ethanoate: BUTYL ACETATE
BUTYL MERCAPTAN
Butyl phthalate: DIBUTYL PHTHALATE

CADMIUM CHLORIDE
Cadmium compounds, soluble: CADMIUM CHLORIDE
CADMIUM NITRATE
CADMIUM SULFATE
Cake alum: ALUMINUM SULFATE
Calcium borate: BORIC ACID
CALCIUM CARBIDE
CALCIUM CYANIDE
CALCIUM HYPOCHLORITE
Calcium oxychloride: CALCIUM HYPOCHLORITE
CALCIUM PHOSPHIDE
Caporit: CALCIUM HYPOCHLORITE
Capryl alcohol: OCTYL ALCOHOL
Carbamic nitrile: CYANAMIDE
Carbide: CALCIUM CARBIDE
Carbinol: METHANOL
Carbodiimide: CYANAMIDE
Carbolic acid: PHENOL
Carbon bisulfide: CARBON DISULFIDE
Carbon chloride: CARBON TETRACHLORIDE
CARBON DISULFIDE
CARBON MONOXIDE
Carbon oxychloride: PHOSGENE
CARBON TETRACHLORIDE
Carbonyl chloride: PHOSGENE
Carboxybenzene: BENZOIC ACID
Catechol: PYROCATECHOL
Cationic detergents: QUATERNARY AMMONIUM SALTS
Cationic surfactants: QUATERNARY AMMONIUM SALTS
Caustic antimony: ANTIMONY TRICHLORIDE
Caustic baryta: BARIUM HYDROXIDE
Caustic potash: POTASSIUM HYDROXIDE
Caustic soda: SODIUM HYDROXIDE
Cetalkonium halides: QUATERNARY AMMONIUM SALTS
Chameleon mineral: POTASSIUM PERMANGANATE
Chinoleine: QUINOLINE
Chinone: QUINONE
Chloramine B: CHLOROAMINES
Chloramine T: CHLOROAMINES
Chloramines: CHLOROAMINES
CHLORIC ACID
CHLORINE
Chlorine cyanide: CYANOGEN CHLORIDE
CHLOROACETIC ACID
CHLOROAMINES
Chloroazotic acid: NITRIC ACID
CHLOROBENZENE
Chlorobenzol: CHLOROBENZENE
CHLOROBUTADIENE
Chloroepoxypropane: EPICHLOROHYDRIN
Chloroethene: VINYL CHLORIDE
Chloroethylene: VINYL CHLORIDE
CHLOROFORM
Chloroformyl chloride: PHOSGENE
Chloronitrobenzene: NITROCHLOROBENZENE
Chloronitrous acid: NITRIC ACID
CHLOROPLATINIC ACID
Chloroprene: CHLOROBUTADIENE
Chloropropene: ALLYL CHLORIDE
Chloropropylene: ALLYL CHLORIDE
CHLOROSULFONIC ACID
CHLOROTHIAZIDE
CHLOROUS ACID
Cinnamene: STYRENE
Cinnamol: STYRENE
Cisbutenedioic acid: MALEIC ACID
Cisbutenedioic anhydride: MALEIC ANHYDRIDE
Citrates: CITRIC ACID
CITRIC ACID
Coal naphtha: BENZENE
Coaltar distillate: BENZENE
Coaltar light oil: BENZENE
Coaltar oil: BENZENE
COBALT CHLORIDE
Cobalt compounds, soluble: COBALT CHLORIDE
COBALT NITRATE
COBALT SULFATE
Cobaltous chloride: COBALT CHLORIDE

Cobaltous nitrate: COBALT NITRATE
Cobaltous sulfate: COBALT SULFATE
Colamine: MONOETHANOLAMINE
Collunosol: TRICHLOROPHENOL
Cologne spirits: ETHYL ALCOHOL
Copperas: FERROUS SULFATE
COPPER CHLORIDE
Copper compounds, soluble: COPPER CHLORIDE
COPPER NITRATE
COPPER SULFATE
Corilagin: TANNIC ACID
Corn sugar: GLUCOSE
Corn syrup: GLUCOSE
Cream of tartar: BORIC ACID
Cresilic acid: PHENOL
CRESOL
Cresylic acid: CRESOL and XYLENOL
CROTONALDEHYDE
Crotonic aldehyde: CROTONALDEHYDE
Crystal ammonia: AMMONIUM CARBONATE
Cupric chloride: COPPER CHLORIDE
Cupric nitrate: COPPER NITRATE
Cupric sulfate: COPPER SULFATE
CYANAMIDE
Cyanide of potash: POTASSIUM CYANIDE
Cyanide of potassium: POTASSIUM CYANIDE
CYANOACETIC ACID
Cyanobenzene: BENZONITRILE
CYANOBUTADIENE
Cyanoethylene: ACRYLONITRILE
Cyanogenamide: CYANAMIDE
CYANOGEN BROMIDE
CYANOGEN CHLORIDE
Cyanogran: SODIUM CYANIDE
Cyanomethane: ACETONITRILE
Cyanoprene: CYANOBUTADIENE
Cyclanon: NEUTRAL SURFACTANTS
Cyclohexadienedione: QUINONE
CYCLOHEXANE
Cyclohexanecarboxylic acid: NAPHTHENIC ACID
Cyclohexatriene: BENZENE
Cyclopan: NEUTRAL SURFACTANTS

Darammon: AMMONIUM CHLORIDE
DBP: DIBUTYL PHTHALATE
DEA: DIETHANOLAMINE
Decaborane: BORANES
DEG: DIETHYLENE GLYCOL
DEP: DIETHYL PHTHALATE
Detergents: ANIONIC SURFACTANTS, NEUTRAL SURFACTANTS and QUATERNARY AMMONIUM SALTS
Detergents, anionic: DISODIUMDIBUTYLPHENYLPHENOLDISULFONATE
Detergents, cationic: QUATERNARY AMMONIUM SALTS
Dextrose: GLUCOSE
Diamine: HYDRAZINE
DIAMINOETHANE
Diaminohexane: HEXAMETHYLENE DIAMINE
DIAMYLAMINE
Diantimony trioxide: ANTIMONY TRIOXIDE
Diazotizing salts: SODIUM NITRITE
Dibasic sodium arsenate: SODIUM ARSENATE
Dibasic sodium phosphate: SODIUM PHOSPHATE
Dibenzopyridine: ACRIDINE
Diborane: BORANES
DIBUTYL PHTHALATE
DICHLOROBENZENE
Dichloroethyl sulfide: MUSTARD GAS
Dichlorodiethyl sulfide: MUSTARD GAS
DICHLOROETHANE
DICHLOROMETHANE
DICHLOROPHENOL
DICHLOROPROPANE
Dicyanobutane: ADIPONITRILE
Diesel fuel oil: PETROLEUM PRODUCTS, MEDIUM
DIETHANOLAMINE
DIETHYLAMINE
Diethyl carbinol: PENTANOL
DIETHYLENE GLYCOL
Diethylolamine: DIETHANOLAMINE
DIETHYL PHTHALATE
Dihydroxybenzene: PYROCATECHOL and RESORCINOL
Dihydroxybutane: BUTYLENE GLYCOL
Dihydroxydiethylamine: DIETHANOLAMINE
Dihydroxydiethyl ether: DIETHYLENE GLYCOL
Dihydroxyethane: ETHYLENE GLYCOL
Dihydroxypropane: PROPYLENE GLYCOL
Diisocyanatotoluene: TOLUENE DIISOCYANATE
DIISOPROPANOLAMINE
DIISOPROPYLAMINE
DIMETHYLAMINE
Dimethylbenzene: XYLENE
Dimethyl carbinol: PROPYL ALCOHOL
Dimethyleneimine: ETHYLENEIMINE
Dimethyl ethyl carbinol: PENTANOL
Dimethylphenol: XYLENOL
DIMETHYL SULFATE
DIMETHYL SULFOXIDE
DINITROBENZENE
Dinitrobenzol: DINITROBENZENE
Dinitrogen monoxide: NITROUS OXIDE
DINITROPHENOL
DIPA: DIISOPROPANOLAMINE
Dipentylamine: DIAMYLAMINE
Disodium arsenate: SODIUM ARSENATE
Disodiumdibutylphenylphenoldisulfonate: ANIONIC SURFACTANTS
Disodium phosphate: SODIUM PHOSPHATE
Disulfatozirconic acid: ZIRCONIUM SULFATE
Disulfur dichloride: SULFUR CHLORIDE
DMA: DIMETHYLAMINE
DMSO: DIMETHYL SULFOXIDE
Dowicide b: TRICHLOROPHENOL

Dowicide 2 and 2s:
  TRICHLOROPHENOL
Duponol: NEUTRAL
  SURFACTANTS
Dutch oil:
  DICHLOROETHANE

Edetates: ETHYLENEDIAMINETETRAACETIC ACID
EDTA: ETHYLENEDIAMINETETRAACETIC ACID
Elayl: ETHYLENE
Enanthyl alcohol: HEPTANOL
Engraver's acid: NITRIC ACID
EPICHLOROHYDRIN
Epoxypropane: PROPYLENE OXIDE
Erinitrit: SODIUM NITRITE
Ethanal: ACETALDEHYDE
Ethanamide: ACETAMIDE
Ethanedioic acid: OXALIC ACID
Ethanediol: ETHYLENE GLYCOL
Ethanenitrile: ACETONITRILE
Ethanodiamine: DIAMINOETHANE
Ethanoic acid: ACETIC ACID
Ethanol: ETHYL ALCOHOL
Ethanolamine: MONOETHANOLAMINE
Ethene: ETHYLENE
Etherin: ETHYLENE
Ethine: ACETYLENE
ETHYL ACRYLATE
ETHYL ALCOHOL
Ethylaldehyde: ACETALDEHYDE
ETHYLAMINE
ETHYLBENZENE
Ethyl benzol: ETHYL BENZENE
ETHYLENE
Ethylene acetate: VINYL ACETATE
Ethylene alcohol ETHYLENE GLYCOL
Ethylenebisiminodiacetic acid: ETHYLENEDIAMINETETRAACETIC ACID
Ethylene bromide: VINYL BROMIDE
Ethylene chloride: DICHLOROETHANE and VINYL CHLORIDE
ETHYLENE CYANOHYDRIN
Ethylenediamine: DIAMINOETHANE
ETHYLENEDIAMINETETRAACETIC ACID
Ethylene dicarboxylic acid: MALEIC ACID
Trans-ethylenedicarboxylic acid: FUMARIC ACID
Ethylenedinitrilotetraacetic acid: ETHYLENEDIAMINETETRAACETIC ACID
ETHYLENE GLYCOL
ETHYLENE GLYCOL DIACETATE
ETHYLENE GLYCOL MONOBUTYL ETHER
ETHYLENEIMINE
Ethyl hydroxide: ETHYL ALCOHOL
Ethylic alcohol: ETHYL ALCOHOL
Ethylidene chloride: DICHLOROETHANE
Ethyl phthalate: DIETHYL PHTHALATE
Ethyl picoline: METHYLETHYL PYRIDINE
Ethylpropanol: PENTANOL
Ethyne: ACETYLENE
Eunatrol: SODIUM OLEATE
Exitelite: ANTIMONY TRIOXIDE

Factitious air: NITROUS OXIDE
Fermentation alcohol: ETHYL ALCOHOL
FERRIC CHLORIDE
Ferric hydrate: FERRIC HYDROXIDE
FERRIC HYDROXIDE
Ferric oxide (hydrated): FERRIC HYDROXIDE
Ferric perchloride: FERRIC CHLORIDE
Ferric sesquisulfate: FERRIC SULFATE
FERRIC SULFATE
Ferric trichloride: FERRIC CHLORIDE
Ferric trisulfate: FERRIC SULFATE
FERROUS HYDROXIDE
FERROUS SULFATE
FERROUS SULFITE
Flores martis: FERRIC CHLORIDE
Fluorocid: SODIUM FLUORIDE
Flowers of antimony: ANTIMONY TRIOXIDE
Flura-Drops: SODIUM FLUORIDE
FLUORINE
FORMALDEHYDE
Formalin: FORMALDEHYDE
FORMIC ACID
Formic aldehyde: FORMALDEHYDE
Formol: FORMALDEHYDE
Formonitrile: HYDROCYANIC ACID
Formyl chloride: CHLOROFORM
Formyl trichloride: CHLOROFORM
FRUCTOSE
Fruit sugar: FRUCTOSE
FUMARIC ACID
Fumigrain: ACRYLONITRILE
Furaldehyde: FURFURAL
Furane carbinol: FURFURYL ALCOHOL
Furanedione: MALEIC ANHYDRIDE
FURFURAL
Furfuralcohol: FURFURYL ALCOHOL
FURFURYL ALCOHOL
Furyl carbinol: FURFURYL ALCOHOL
Fyrex: AMMONIUM PHOSPHATE

GALLIC ACID
Gallotannic acid: TANNIC ACID
Gallotannin: TANNIC ACID
Gardenal: PHENOBARBITAL
Gardinol detergents: NEUTRAL SURFACTANTS
Gaseous hydrocarbons: PETROLEUM PRODUCTS, LIGHT
Gasoline: PETROLEUM PRODUCTS, LIGHT
Glacial acetic acid: ACETIC ACID
Glucitol: SORBITOL
GLUCONIC ACID
GLUCOSE
Glycerine: GLYCEROL
GLYCEROL
Glycogenic acid: GLUCONIC ACID
Glycol cyanohydrin: ETHYLENE CYANOHYDRIN
Glycol diacetate: ETHYLENE GLYCOL DIACETATE
Glyconic acid: GLUCONIC ACID
Glycyl alcohol: GLYCEROL
Grain alcohol: ETHYL ALCOHOL
Grape sugar: GLUCOSE
Green quinhydrone: QUINHYDRONE
Green vitriol: FERROUS SULFATE
Gulitol: SORBITOL

Hartshorn: AMMONIUM CARBONATE
HD: MUSTARD GAS
Heavy carburetted hydrogen: ETHYLENE
Heavy greases: PETROLEUM PRODUCTS, HEAVY
HEPTANOL
Heptyl alcohol: HEPTANOL
Heptyl carbinol: OCTYL ALCOHOL
Hexahydric alcohol: SORBITOL
Hexahydrobenzene: CYCLOHEXANE
Hexahydrobenzoic acid: NAPHTHENIC ACID
Hexamethylene: CYCLOHEXANE
HEXAMETHYLENE DIAMINE
Hexanaphthene: CYCLOHEXANE
Hexane: PETROLEUM PRODUCTS, LIGHT
Hexane diamine: HEXAMETHYLENE DIAMINE
Hexanedioic acid: ADIPIC ACID
HEXANOL
Hexone: METHYLISOBUTYL KETONE
Hexyl alcohol: HEXANOL
HTH: CALCIUM HYPOCHLORITE and HYPOCHLOROUS ACID
Hydracrylonitrile: ETHYLENE CYANOHYDRIN
HYDRAZINE
HYDROCHLORIC ACID
HYDROCYANIC ACID
HYDROFLUORIC ACID
Hydrogen carboxylic acid: FORMIC ACID
Hydrogen chloride: HYDROCHLORIC ACID
Hydrogen cyanamide: CYANAMIDE
Hydrogen cyanide: HYDROCYANIC ACID
Hydrogen dioxide: HYDROGEN PEROXIDE
HYDROGEN PEROXIDE
Hydrogen sulfate: SULFURIC ACID
Hydroquinol: HYDROQUINONE
HYDROQUINONE
Hydroxybenzaldehyde: SALICYLALDEHYDE
Hydroxybenzene: PHENOL
Hydroxybenzoic acid: SALICYLIC ACID
Hydroxycarballylic acid: CITRIC ACID
Hydroxydimethylbenzene: XYLENOL
Hydroxydinitrobenzene: DINITROPHENOL
Hydroxyethylamine: MONOETHANOLAMINE
bis(Hydroxyethyl)amine: DIETHANOLAMINE
Hydroxyethylethylenediamine: AMINO ETHYL ETHANOL AMINE
Hydroxyheptane: HEPTANOL
Hydroxyisobutyronitrile: ACETONE CYANOHYDRIN
HYDROXYLAMINE
Hydroxymethylfuran: FURFURYL ALCOHOL
Hydroxynaphthalene: NAPHTHOL
Hydroxyphenol: RESORCINOL
Hydroxypropanetricarboxylic acid: CITRIC ACID
Hydroxypropanoic acid: LACTIC ACID
Hydroxypropionitrile: ETHYLENE CYANOHYDRIN
Hydroxypropylamine: MONOISOPROPANOLAMINE
Hydroxytoluene: CRESOL
Hypnone: ACETOPHENONE
HYPOCHLOROUS ACID
Hyponitrous anhydride: NITROUS OXIDE

Iminodiethanol: **DIETHANOLAMINE**
INDOLE
Iron chloride: **FERRIC CHLORIDE**
Iron hydrate: **FERRIC HYDROXIDE**
Iron hydroxide: **FERRIC HYDROXIDE** and **FERROUS HYDROXIDE**
Iron oxide (hydrated): **FERRIC HYDROXIDE**
Iron perchloride: **FERRIC CHLORIDE**
Iron persulfate: **FERRIC SULFATE**
Iron sulfate: **FERRIC SULFATE** and **FERROUS SULFATE**
Iron tersulfate: **FERRIC SULFATE**
Iron trichloride: **FERRIC CHLORIDE**
Iron vitriol: **FERROUS SULFATE**
Isoamyl acetate: **AMYL ACETATE**
ISOPRENE
Isopropanol: **PROPYL ALCOHOL**
Isopropylacetone: **METHYLISOBUTYL KETONE**
Isopropyl alcohol: **PROPYL ALCOHOL**
Isovaleral: **PENTANAL**
Isovaleraldehyde: **PENTANAL**
Isovaleric aldehyde: **PENTANAL**
Irium: **NEUTRAL SURFACTANTS**

Jet fuels: PETROLEUM
PRODUCTS, MEDIUM

Karidium: SODIUM
  FLUORIDE
Kerosine: PETROLEUM
  PRODUCTS, MEDIUM

LACTIC ACID
LACTOSE
Lanarkite: LEAD SULFATE
LANTHANUM ACETATE
Laughing gas: NITROUS OXIDE
Lavacol: ETHYL ALCOHOL
LEAD ACETATE
LEAD ARSENATE
LEAD CHLORIDE
LEAD NITRATE
Lead orthoarsenate: LEAD ARSENATE
LEAD SULFATE
LEAD TETRAETHYL
Leucoline: QUINOLINE
Levulose: FRUCTOSE
Lichenic acid: FUMARIC ACID
Light solvents: PETROLEUM PRODUCTS, LIGHT
Ligroin: PETROLEUM PRODUCTS, LIGHT
LINOLEIC ACID
Linolic acid: LINOLEIC ACID
Linseed oil: LINOLEIC ACID
Liquefied gases: PETROLEUM PRODUCTS, LIGHT
Lissapol: NEUTRAL SURFACTANTS
LITHIUM CHLORIDE
Losantin: CALCIUM HYPOCHLORITE
Lubricants: PETROLEUM PRODUCTS, HEAVY
Lubricating oils: PETROLEUM PRODUCTS, MEDIUM
Luminal: PHENOBARBITAL
Lye: POTASSIUM HYDROXIDE and SODIUM HYDROXIDE
Lysol: CRESOL

MALEIC ACID
MALEIC ANHYDRIDE
Maleinic acid: MALEIC ACID
Malonic nitrile: CYANOACETIC ACID
Maltobiose: MALTOSE
MALTOSE
Malt sugar: MALTOSE
MCA: CHLORACETIC ACID
MEA: MONOETHANOLAMINE
MEP: METHYLETHYL PYRIDINE
Mercaptoacetic acid: THIOGLYCOLIC ACID
Mercaptomethane: METHANETHIOL
Methanal: FORMALDEHYDE
METHANETHIOL
Methanoic acid: FORMIC ACID
METHANOL
METHYL ACETATE
Methylacetic acid: PROPANOIC ACID
Methylacetic anhydride: PROPANOIC ANHYDRIDE
Methylacrolein: CROTONALDEHYDE
METHYL ACRYLATE
Methyl alcohol: METHANOL
METHYLAMINE
Methyl amyl carbinol: HEPTANOL
Methylaniline: TOLUIDINE
METHYL AZIDE
Methylbenzene: TOLUENE
Methyl butadiene: ISOPRENE
Methylbutanol: PENTANOL
Methylbutyl alcohol: PENTANOL
Methylbutyraldehyde: PENTANAL
Methyl carbinol: ETHYL ALCOHOL
Methyl cyanide: ACETONITRILE
Methylene chloride: DICHLOROMETHANE
Methylene dichloride: DICHLOROMETHANE
Methylethylene glycol: PROPYLENE GLYCOL
Methylethylethylene: PENTENE
METHYLETHYL PYRIDINE
Methyl glycol: PROPYLENE GLYCOL
Methylhexyl carbinol: OCTYL ALCOHOL
METHYLISOBUTYL KETONE
Methyllactonitrile: ACETONE CYANOHYDRIN
Methyl mercaptan: METHANETHIOL
METHYLMETHACRYLATE
Methylnitrophenol: NITROCRESOL
Methylpentanone: METHYLISOBUTYL KETONE
Methylphenol: CRESOL
Methyl propenoate: METHYL ACRYLATE
Methyl propyl carbinol: PENTANOL
Methyl sulfhydrate: METHANETHIOL
Methyl sulfoxide: DIMETHYL SULFOXIDE
Methyltoluene: XYLENE
Methyl trichloride: CHLOROFORM
MIBK: METHYLISOBUTYL KETONE
Milk acid: LACTIC ACID
Milk sugar: LACTOSE
MIPA: MONOISOPROPANOLAMINE
Mixed acid: NITRIC ACID
Modinal: NEUTRAL SURFACTANTS
MOLASSES
Molybdenum trioxide: MOLYBDIC ANHYDRIDE
Molybdic acid anhydride: MOLYBDIC ANHYDRIDE
MOLYBDIC ANHYDRIDE
Molybdic oxide: MOLYBDIC ANHYDRIDE
Monobasic sodium phosphate: SODIUM PHOSPHATE
Monochloroacetic acid: CHLOROACETIC ACID
MONOETHANOLAMINE
Monoethylamine: ETHYLAMINE
MONOISOPROPANOLAMINE
Monomethylamine: METHYLAMINE
Mononitrogen monoxide: NITRIC OXIDE
Moprofix: NEUTRAL SURFACTANTS
Moringine: BENZYLAMINE
Muriatic acid: HYDROCHLORIC ACID
MUSTARD GAS

Nacconate: TOLUENE
  DIISOCYANATE
NAPHTHALENE
Naphthalene dicarboxylic acid:
  NAPHTHALENE
NAPHTHALIC ACID
Naphthalidine: NAPHTHYLAMINE
Napthalin: NAPHTHALENE
Naphthene: NAPHTHALENE
NAPHTHENIC ACID
NAPHTHOL
NAPHTHYLAMINE
Natrium: SODIUM
Neutral potassium chromate:
  POTASSIUM CHROMATE
Neutral sodium chromate:
  SODIUM CHROMATE
Neutral spirits: ETHYL
  ALCOHOL
NEUTRAL SURFACTANTS
NICKEL AMMONIUM SULFATE
NICKEL CHLORIDE
NICKEL NITRATE
Nickelous chloride:
  NICKEL CHLORIDE
Nickelous nitrate:
  NICKEL NITRATE
Nickelous sulfate:
  NICKEL SULFATE
NICKEL SULFATE
Nitraniline: NITROANILINE
Nitrate of ammonia:
  AMMONIUM NITRATE
Nitrating acid: NITRIC ACID
NITRIC ACID
NITRIC OXIDE
NITROANILINE
NITROBENZENE
Nitrobenzol: NITROBENZENE
NITROCHLOROBENZENE
NITROCRESOL
NITROGEN DIOXIDE
Nitrogen monoxide:
  NITRIC OXIDE
NITROGEN TETROXIDE
Nitrohydrochloric acid:
  NITRIC ACID
Nitromuriatic acid: NITRIC ACID
NITROPHENOL
NITROPROPANE
NITROUS ACID
NITROUS OXIDE
Nitroxylene: NITROXYLOL
NITROXYLOL
n-octyl sodium sulfate:
  NEUTRAL SURFACTANTS
Normal sodium pyrophosphate:
  SODIUM PHOSPHATE
Norway saltpeter:
  AMMONIUM NITRATE
Nutgall extract: TANNIC ACID

Octadecandienoic acid:
LINOLEIC ACID
Octadecenoic acid:
OLEIC ACID
Octanol: OCTYL ALCOHOL
OCTYL ALCOHOL
n-Octyl sodium sulfate:
NEUTRAL SURFACTANTS
Odpn: OXYPROPIONITRILE
Oil of mirbane:
NITROBENZENE
Oil of vitriol:
SULFURIC ACID
Olefiant gas: ETHYLENE
OLEIC ACID
Oleic acid sodium salt:
SODIUM OLEATE
Oleum: SULFURIC ACID
OXALIC ACID
Oxammonium: HYDROXYLAMINE
Oxydiethanol:
DIETHYLENE GLYCOL
Oxymethylene: FORMALDEHYDE
OXYPROPIONITRILE

Paradihydroxybenzene: HYDROQUINONE
Paraform: PARAFORMALDEHYDE
PARAFORMALDEHYDE
Paraldehyde: ACETALDEHYDE
Paste waxes: PETROLEUM PRODUCTS, HEAVY
Patent alum: ALUMINUM SULFATE
Pear oil: AMYL ACETATE
Pentacetate: AMYL ACETATE
PENTANAL
PENTANE
Pentanedieneonitrile: CYANOBUTADIENE
PENTANOL
Pentanol acetate: AMYL ACETATE
PENTENE
PERCHLORIC ACID
Perchloromethane: CARBON TETRACHLORIDE
Perchloron: CALCIUM HYPOCHLORITE and HYPOCHLOROUS ACID
Peroxide: HYDROGEN PEROXIDE
PETROLEUM CRUDE
PETROLEUM PRODUCTS, HEAVY
PETROLEUM PRODUCTS, LIGHT
PETROLEUM PRODUCTS, MEDIUM
Phene: BENZENE
Phenic acid: PHENOL
PHENOBARBITAL
Phenobarbitone: PHENOBARBITAL
PHENOL
N-Phenylacetamide: ACETANILIDE
Phenylamine: ANILINE
Phenylbarbituric acid: PHENOBARBITAL
PHENYLCARBYLAMINE CHLORIDE
Phenyl chloride: CHLOROBENZENE
Phenyl cyanide: BENZONITRILE
Phenylethane: ETHYL BENZENE
Phenylethylene: STYRENE
Phenylformic acid: BENZOIC ACID
Phenyl hydride: BENZENE
Phenylic acid: PHENOL
Phenylmethane: TOLUENE
Phenylmethylamine: BENZYLAMINE
Phenyl methyl ketone: ACETOPHENONE
PHOSGENE
PHOSPHORIC ACID
Phosphoric sulfide: PHOSPHORUS PENTASULFIDE
PHOSPHORUS
Phosphorus chloride: PHOSPHORUS TRICHLORIDE
PHOSPHORUS OXYCHLORIDE
PHOSPHORUS PENTASULFIDE
Phosphorus persulfide: PHOSPHORUS PENTASULFIDE
PHOSPHORUS TRICHLORIDE
Phosphoryl chloride: PHOSPHORUS OXYCHLORIDE
Photophor: CALCIUM PHOSPHIDE
Phthalic acid dibutyl ester: DIBUTYL PHTHALATE
Platinic chloride: CHLOROPLATINIC ACID
Polyether glycol: POLYGLYCOL ETHER
POLYGLYCOL ETHER
Potash hydrate: POTASSIUM HYDROXIDE
Potassium antimonyl tartrate: ANTIMONY POTASSIUM TARTRATE
Potassium bichromate: POTASSIUM DICHROMATE
Potassium borotartrate: BORIC ACID
POTASSIUM CHROMATE
POTASSIUM CYANIDE
POTASSIUM DICHROMATE
POTASSIUM HYDROXIDE
POTASSIUM PERMANGANATE
Proof spirits: ETHYL ALCOHOL
PROPANAL
Propane: PETROLEUM PRODUCTS, LIGHT
Propanediol: PROPYLENE GLYCOL
Propanetriol: GLYCEROL
PROPANOIC ACID
PROPANOIC ANHYDRIDE

Propanol: PROPYL ALCOHOL
Propenenitrile: ACRYLONITRILE
Propenoic acid: ACRYLIC ACID
Propenol: ALLYL ALCOHOL
Propene oxide: PROPYLENE OXIDE
Propenyl alcohol: ALLYL ALCOHOL
Propionaldehyde: PROPANAL
Propionic acid: PROPANOIC ACID
Propionic aldehyde: PROPANAL
Propionic anhydride: PROPANOIC ANHYDRIDE
PROPYL ALCOHOL
Propyl aldehyde: PROPANAL
PROPYLAMINE
Propylene dichloride: DICHLOROPROPANE
PROPYLENE GLYCOL
PROPYLENE OXIDE
Propylethylene: PENTENE
Prussic acid: HYDROCYANIC ACID
PYRIDINE
Pyrocatechin: PYROCATECHOL
PYROCATECHOL
Pyrogallic acid: PYROGALLOL
PYROGALLOL
Pyromucic aldehyde: FURFURAL

Quaternary amines:
  QUATERNARY AMMONIUM SALTS
QUATERNARY AMMONIUM SALTS
QUINACRINE HYDROCHLOIDE
QUINHYDRONE
Quinidine: QUININE
QUININE
Quinol: HYDROQUINONE
QUINOLINE
QUINONE

Red oil: ANILINE and
TOLUENE
Red potassium chromate:
POTASSIUM DICHROMATE
Red prussiate of soda:
SODIUM FERRICYANIDE
Residual fuel oil:
PETROLEUM PRODUCTS, HEAVY
Resorcin: RESORCINOL
RESORCINOL
Road oil: PETROLEUM
PRODUCTS, HEAVY
Roccal: DIMETHYLBENZYLAMMONIUM
CHLORIDE and QUATERNARY
AMMONIUM SALTS

Safflower oil: LINOLEIC ACID
Saccharum lactis: LACTOSE
Sal ammoniac: AMMONIUM CHLORIDE
Sal chalybdis: FERROUS SULFATE
SALICYLIC ACID
Salicylic aldehyde: SALICYLALDEHYDE
Salicylal: SALICYLALDEHYDE
SALICYLALDEHYDE
Salmiac: AMMONIUM CHLORIDE
Sandopan: NEUTRAL SURFACTANTS
Santomerse: ANIONIC SURFACTANTS
Sardipan: NEUTRAL SURFACTANTS
Saturated cycloalkyl fatty acids: NAPHTHENIC ACID
SELENIUM
Selenium compounds: SELENIUM
Senarmontite: ANTIMONY TRIOXIDE
SILVER
Silver salt: ANIONIC SURFACTANTS
SLUDGE, CHEMICAL
SLUDGE, DIGESTED SEWAGE
SLUDGE, RAW UNDIGESTED SEWAGE
SODIUM
Sodium acid sulfite: SODIUM BISULFITE
Sodium anthraquinone sulfonate: ANIONIC SURFACTANTS
SODIUM ARSENATE
SODIUM AZIDE
Sodium benzoate: BENZOIC ACID
Sodium bichromate: SODIUM DICHROMATE
Sodium bisulfide: SODIUM HYDROSULFIDE
SODIUM BISULFITE
Sodium borate: BORIC ACID
Sodium bromobenzene sulfonate: ANIONIC SURFACTANTS
Sodium cetylate: SODIUM PALMITATE
Sodium chlorothiazide: CHLOROTHIAZIDE
SODIUM CHROMATE
SODIUM CYANATE
SODIUM CYANIDE
Sodium decylbenzene sulfonate: ANIONIC SURFACTANTS
Sodium dichlorobenzene sulfonate: ANIONIC SURFACTANTS
SODIUM DICHROMATE
Sodium dinitrophenol: DINITROPHENOL
Sodium dodecylbenzene sulfonate: ANIONIC SURFACTANTS
SODIUM FERRICYANIDE
SODIUM FERROCYANIDE
SODIUM FLUORIDE
Sodium fluorosilicate: SODIUM FLUOSILICATE
SODIUM FLUOSILICATE
Sodium hexacyanoferrate (III): SODIUM FERRICYANIDE
Sodium hexacyanoferrate (II): SODIUM FERROCYANIDE
Sodium hexadecanoate: SODIUM PALMITATE
Sodium hexadecylate: SODIUM PALMITATE
Sodium hydrate: SODIUM HYDROXIDE
Sodium hydrogen sulfide: SODIUM HYDROSULFIDE
Sodium hydrogen sulfite: SODIUM BISULFITE
SODIUM HYDROSULFIDE
SODIUM HYDROXIDE
Sodium lauryl sulfate: NEUTRAL SURFACTANTS
Sodium metabisulfite: SODIUM BISULFITE

Sodium methoxide: SODIUM METHYLATE
SODIUM METHYLATE
Sodium monobutyldiphenyl sulfonate: ANIONIC SURFACTANTS
Sodium monobutylphenylphenol monosulfonate: ANIONIC SURFACTANTS
Sodium monosulfide: SODIUM SULFIDE
Sodium naphthalene sulfate: ANIONIC SURFACTANTS
SODIUM NITRITE
Sodium nitrochlorobenzene sulfonate: ANIONIC SURFACTANTS
Sodium octadecanoate: SODIUM STEARATE
SODIUM OLEATE
SODIUM PALMITATE
SODIUM PHOSPHATE
Sodium prussiate yellow: SODIUM FERROCYANIDE
Sodium rhodanate: SODIUM THIOCYANATE
Sodium rhodanide: SODIUM THIOCYANATE
Sodium salts of sulfated fatty alcohols: NEUTRAL SURFACTANTS
SODIUM SILICATE
Sodium silicofluoride: SODIUM FLUOSILICATE
SODIUM STEARATE
Sodium sulfhydrate: SODIUM HYDROSULFIDE
SODIUM SULFIDE
SODIUM SULFITE
Sodium sulfoanthroquinone: ANIONIC SURFACTANTS
Sodium sulfocyanate: SODIUM THIOCYANATE
Sodium sulfocyanide: SODIUM THIOCYANATE
Sodium sulfuret: SODIUM SULFIDE
SODIUM THIOCYANATE
SODIUM TUNGSTATE
Sodium wolframate: SODIUM TUNGSTATE
Sorbit: SORBITOL
SORBITOL
Spent sulfuric acid: SULFURIC ACID
Spirit of Mindererus: AMMONIUM ACETATE
Spirit of wine: ETHYL ALCOHOL
STANNOUS CHLORIDE
Starch syrup: GLUCOSE
Stearic acid sodium salt: SODIUM STEARATE
STRONTIUM CHLORIDE
STRONTIUM NITRATE
STYRENE
Styrol: STYRENE
Styrolene: STYRENE
Sugar of lead: LEAD ACETATE
SULFUR CHLORIDE
SULFUR DIOXIDE
Sulfuric chlorohydrin: CHLOROSULFONIC ACID
Sulfur monochloride: SULFUR CHLORIDE
Sulfur mustard: MUSTARD GAS
Sulfur subchloride: SULFUR CHLORIDE
SULFURIC ACID
SULFUROUS ACID
Sulfurous anhydride: SULFUR DIOXIDE
Sulfur dioxide solution: SULFUROUS ACID
Sulfurous oxide: SULFUR DIOXIDE
Superoxol: HYDROGEN PEROXIDE
SUPERPHOSPHATE
Surfactants, anionic: DISODIUMDIBUTYLPHENYLPHENOL-DISULFONATE
Surfactants, cationic: QUATERNARY AMMONIUM SALTS
Sylvic acid: ABIETIC ACID

Tall oil: LINOLEIC ACID
TANNIC ACID
Tannin: TANNIC ACID
Tar camphor: NAPHTHALENE
Tartar emetic: ANTIMONY POTASSIUM TARTRATE
Tartarized antimony: ANTIMONY POTASSIUM TARTRATE
Tartrated antimony: ANTIMONY POTASSIUM TARTRATE
TASP: SODIUM PHOSPHATE
TDI: TOLUENE DIISOCYANATE
TEA: TRIETHANOLAMINE
Tecquinol: HYDROQUINONE
Teepol: NEUTRAL SURFACTANTS
TEPA: TETRAETHYLENE PENTAMINE
Tergavon: NEUTRAL SURFACTANTS
TETA: TRIETHYLENETETRAMINE
Tetrachloromethane: CARBON TETRACHLORIDE
TETRAETHYLENE PENTAMINE
Tetraethyl lead: LEAD TETRAETHYL
Tetramethylene cyanide: ADIPONITRILE
Tetramethylene dicyanide: ADIPONITRILE
Tetra sodium pyrophosphate: SODIUM PHOSPHATE
THALLIUM
Thallium compounds: THALLIUM
THIOGLYCOLIC ACID
Thioglycollic acid: THIOGLYCOLIC ACID
Thiomethyl alcohol: METHANETHIOL
Thiophosphoric anhydride: PHOSPHORUS PENTASULFIDE
THORIUM CHLORIDE
THORIUM NITRATE
Thorium tetrachloride: THORIUM CHLORIDE
Tin crystals: STANNOUS CHLORIDE
Tin dichloride: STANNOUS CHLORIDE
Tin protochloride: STANNOUS CHLORIDE
Tin salt: STANNOUS CHLORIDE
Titanate compounds: TITANIUM COMPOUNDS
TITANIUM COMPOUNDS
Titanous compounds: TITANIUM COMPOUNDS
Titanyl compounds: TITANIUM COMPOUNDS
TMA: TRIMETHYLAMINE
TOLUENE
TOLUENE DIISOCYANATE
TOLUIDINE
Toluol: TOLUENE
Tolylene diisocyanate: TOLUENE DIISOCYANATE
Toxilic acid: MALEIC ACID
Toxilic anhydride: MALEIC ANHYDRIDE
Tribasic sodium phosphate: SODIUM PHOSPHATE
Trichlorex: TRICHLOROPHENOL
Trichloromethane: CHLOROFORM
TRICHLOROPHENOL
TRIETHANOLAMINE
TRIETHYLAMINE
TRIETHYLENETETRAMINE
Trihydroxybenzene: PYROGALLOL
Trihydroxybenzoic acid: GALLIC ACID
Trihydroxyethylamine: TRIETHANOLAMINE
TRIMETHYLAMINE
Trimethylene glycol: PROPYLENE GLYCOL
Triple superphosphate: SUPERPHOSPHATE
Trisodium arsenate: SODIUM ARSENATE

TSPP: SODIUM PHOSPHATE
Turbine fuels: PETROLEUM
   PRODUCTS, MEDIUM
Turkey red oil: OLEIC ACID

Unrefined petroleum:
   PETROLEUM, CRUDE

Valentinite: ANTIMONY TRIOXIDE
Valeral: PENTANAL
Valeraldehyde: PENTANAL
Valeric aldehyde: PENTANAL
Vanadic sulfate: VANADYL SULFATE
Vanadium oxysulfate: VANADYL SULFATE
Vanadium sulfate: VANADYL SULFATE
VANADYL SULFATE
VC: VINYL CHLORIDE
Ventox: ACRYLONITRILE
Villiaumite: SODIUM FLUORIDE
Vinegar: ACETIC ACID
VINYL ACETATE
Vinylacrylonitrile: CYANOBUTADIENE
VINYL BROMIDE
Vinyl carbinol: ALLYL ALCOHOL
VINYL CHLORIDE
Vinyl cyanide: ACRYLONITRILE
Vinylformic acid: ACRYLIC ACID

Water glass:
SODIUM SILICATE
Weisspiessglanz:
ANTIMONY TRIOXIDE
White caustic:
SODIUM HYDROXIDE
Wood alcohol:
METHANOL
Wood spirit: METHANOL

XYLENE
XYLENOL
Xylol: XYLENE

Yellow prussiate of soda:
SODIUM FERROCYANIDE

ZINC COMPOUNDS
ZINCONIUM SULFATE
Zymafluor: SODIUM FLUORIDE

ZI-ZY

APPENDIX C

CATEGORIZATION OF HAZARDOUS POLLUTING SUBSTANCES

There are seventeen categories:

The Categories	NOTES
1. Solid-soluble 2. Solid-insoluble-floats 3. Solid-insoluble-sinks 4. Liquid-miscible 5. Liquid-immiscible-floats 6. Liquid-immiscible-sinks	These categories indicate whether the spill dissolves, or is visible on the surface or bottom. A fine powder may float or remain suspended even if it is heavier than water.
7. Gas	Applies if there was spill on the ground but no visible trace remains.
8. Color: red, yellow, green, blue, misc.	The color of the bulk substance or a strong solution.
9. Fumes	Observed only at time of spill or soon after.
10. Vigorous reaction	On contact with water, rapid generation of gas, heat, noise, flame, explosion.
11. Odor-unpleasant 12. Odor-not unpleasant	Unpleasant odors are disagreeable even at low concentration. The others may be disagreeable at high concentration.
13. Lacrimatory	Induce eye watering even at low concentration; many others do at high concentration.
14. Flammable	CAUTION: test a small sample, well away from the spill.

15. Acid 16. Alkaline	Give a clear reaction (e.g., litmus red/blue) at low concentration.
17. Froth	Readily form persistent froth.

Using the Categorization: (a) Observations

	APPLICABLE CATEGORIES
- Be alert for odor and lacrimation when first approaching the spill, and throughout survey.	11,12,13
- Look for solid or liquid in the water, and on the ground if spilled inshore.	1,2,3,4,5,6,7
- Look for abnormal color in the water, and on the ground if spilled inshore.	8
- Ask witnesses of the spill about fumes and vigorous reaction.	9,10
- If a sample of the spill can be collected from the water surface or inshore, test for flammability. If negative, try an improvised wick, extra shelter from wind, etc. Test a SMALL sample, WELL AWAY from the spill.	14
- Test the water with litmus paper. Check a reference sample of water from outside the spill zone.	15,16
- If there is natural turbulence (rapids, falls), look for persistent froth; if not, shake a sample in a glass container. Check a reference sample of water from outside the spill zone.	17

Using the Categorization: (b) Elimination

- Note which categories apply to the observed properties of the spill.
- Note which substances appear in all or most of these categories.
- Check the data for each of these substances in the Dictionary.
- Determine which is the most likely candidate.
- Apply confirmatory tests. If the identification is uncertain, test other candidates.

EXAMPLE: The spill is observed as a surface film of colorless liquid with an aromatic hydrocarbon (benzene-like) odor. Category 5 (Liquid-insoluble-floats) reduces the possibilities to 32. Category 12 (Odor-not unpleasant: benzene) reduces the possibilities to 5: benzene, ethyl benzene, styrene, toluene, xylene. A cross-check with Category 8 (Color) verifies that none of these 5 is colored. Category 14 (Flammability) shows benzene as highly flammable, the others less so; but this would not be decisive. The individual Dictionary entries show no definitive field test, but indicate that the properties of all five are sufficiently similar for damage investigation to proceed while positive identification is made at a permanent laboratory.

Limitations

- The substances are categorized according to their usual properties, but the spill may have an unusual color, smell, etc., due to impurities.
- A few substances are not listed at all, because their obvious characteristics are too variable or ill-defined.
- The physical state of the spill (solid/liquid/gas) may be different in cold or hot weather.
- Odor is difficult to describe and identify, and individual reactions vary widely.

Category I: Solid-soluble

Acetamide
Alkyl aryl ammonium halide
Aluminum sulfate
Ammonium compounds
Antimony trifluoride
Barium chloride
Barium cyanide
Beryllium chloride
Beryllium nitrate
Beryllium sulfate (hydrated)
Borates (most)
tert-Butyl alcohol
Cadmium chloride
Cadmium nitrate
Cadmium sulfate
Calcium cyanide
Chloroacetic acid
Chloroplatinic acid
Citric acid
Cobalt chloride
Cobalt nitrate
Cobalt sulfate
Copper chloride
Copper nitrate
Copper sulfate
Cyanamide
Cyanacetic acid
Cyanogen bromide
Diisopropanolamine
Ferric chloride
Ferric sulfate (hydrated)
Ferrous sulfate
Fructose
Glucose
Hexamethylene diamine
Hydroxylamine
Lactose
Lanthanum acetate
Lead acetate
Lead nitrate
Lithium chloride
Maleic acid
Maltose

Nickel ammonium sulfate
Nickel chloride
Nickel nitrate
Nickel sulfate
Phenobarbital (sodium salt)
Phosphoric acid
Phosphorus pentasulfide (decomp.)
Potassium hydroxide
Pyrocatechol
Pyrogallol
Quinacrine hydrochloride
Resorcinol
Silver nitrate
Sodium hydroxide
Sodium salts (most)
Sorbitol
Stannous chloride (white sediment)
Strontium chloride
Strontium nitrate
Tannic acid
Thallium acetate
Thorium chloride
Thorium nitrate
Vanadyl sulfate
Zinc chloride
Zinc nitrate
Zinc sulfate
Zirconium sulfate

Category 2: Solid-insoluble-floats (See note to Category 3.)

Maleic anhydride
Sodium (reacts violently; products dissolve)

Category 3: Solid-insoluble-sinks

NOTE that sinking is the expected behavior of compact masses of the substance. Fine crystals or fluffy aggregates may float, or fine powders remain in suspension for a long time.

Acetanilide
Acridine
Adipic acid
Aluminum fluoride
Antimony trioxide
Benzoic acid
Beryllium sulfate (anhydrous)
Calcium carbide (reacts)
Calcium phosphide (reacts)
Dichlorobenzene (para-)
Dichlorophenol
Ferric hydroxide
Ferrous hydroxide
Ferrous sulfite
Fumaric acid
Gallic acid
Lead arsenate
Lead chloride
Lead sulfate
Molybdic anhydride
Naphthalene
Naphthalic acid
Naphthol
Naphthylamine
Nitroaniline
Nitrochlorobenzene
Nitrocresol
Nitrophenol
Quinhydrone
Quinine
Quinone
Salicylic acid
Sodium fluosilicate
Superphosphate
Toluene diisocyanate (reacts)
Trichlorophenol

Category 4: Liquid-miscible

Acetaldehyde
Acetic acid
Acetic anhydride
Acetone cyanohydrin
Acetonitrile
Acetyl bromide (decomp.)
Acrylic acid
Acrylonitrile
Allyl alcohol
Amino ethyl ethanol amine
Benzylamine
Butylamine
1, 3-Butylene glycol
Chloric acid
Chlorosulfonic acid (reacts violently)
Chlorous acid
Cyanogen chloride
Diaminoethane
Diethanolamine
Diethylamine
Diethylene glycol
Dimethylamine (water solution)
Dimethyl sulfoxide
Ethyl alcohol
Ethylamine
Ethylene cyanohydrin
Ethylene glycol
Ethylene glycol diacetate
Ethylene glycol monobutyl ether
Ethyleneimine
Formaldehyde (water solution)
Formic acid
Furfuryl alcohol
Glycerol
Hydrazine
Hydrochloric acid
Hydrofluoric acid
Hydrogen peroxide
Hypochlorous acid
Lactic acid
Methanol
Methyl acetate

Monoethanolamine
Monoisopropanolamine
Nitric acid
Nitrogen tetroxide (decomp.)
Nitrous acid
Oxydiproprionitrile
Perchloric acid
Phosphorous trichloride (decomp.)
Polyglycol ether
Propanal
Propanoic acid
Propyl alcohol
Propylamine
Propylene glycol
Propylene oxide
Pyridine
Sulfur chloride (reacts)
Sulfuric acid
Sulfurous acid
Tetraethylene pentamine
Thioglycolic acid
Titanium tetrachloride (reacts violently: sediment)
Triethanolamine
Triethylene tetramine
Trimethylamine

Category 5: Liquid-immiscible-floats

Adiponitrile
Allyl chloride
n-Amyl acetate
Benzene
n-Butyl acetate
n-Butyl acrylate
Butyl alcohols (exc. tert-)
Butyl mercaptan
Crotonaldehyde
Cyclohexane
Diamylamine
Diisopropylamine (volatile)
Ethyl acrylate
Ethyl benzene
Heptanol
Hexanol
Isoprene
Linoleic acid
Methanethiol (very volatile)
Methyl acrylate
Methylisobutyl ketone
Methyl methacrylate
Octyl alcohol
Oleic acid
Pentanal
Pentane (volatile)
Pentene (volatile)
Petroleum, crude and products
Styrene
Toluene
Vinyl acetate
Xylene

Category 6: Liquid-immiscible-sinks

Carbon disulfide
Carbon tetrachloride
Chlorobenzene
Chloroform
Dichloroethane
Dichloromethane
Dichloropropane
Diethyl phthlate
Epichlorohydrin
Lead tetraethyl
Mustard gas
Nitrobenzene
Nitroxylol
Phenylcarbylamine chloride
Phosphorus oxychloride (reacts)
Salicylaldehyde
Toluene diisocyanate (reacts)
Vinyl bromide

Category 7: Gas

No persistent visible trace of substance spilt on land or other surface outside the water.

Acetylene
Ammonia
Carbon monoxide
Chlorine
Dimethylamine
Ethylene
Fluorine
Methanethiol (if warm)
Methylamine
Nitric oxide
Nitrogen dioxide/tetroxide
Nitrous oxide
Phosgene
Sulfur dioxide
Vinyl bromide
Vinyl chloride

Category 8: Color

Red

- Ammonium dichromate (red-orange)
- Ammonium ferricyanide
- Cobalt nitrate
- Potassium dichromate
- Sodium ferricyanide
- Sodium dichromate

Yellow

- Ammonium chromate
- Ammonium picrate
- Ammonium sulfide
- Ferric sulfate
- Nitric acid (undiluted)
- Nitroaniline
- Nitrochlorobenzene
- Nitrocresol
- Nitroxylol
- Phenylcarbylamine chloride
- Potassium chromate
- Sodium ferrocyanide
- Sodium chromate
- Quinacrine hydrochloride
- Quinone
- Titanium tetrachloride

Green

- Nickel ammonium sulfate
- Nickel nitrate
- Quinhydrone

Blue

- Copper nitrate
- Copper sulfate
- Sodium fluoride (color added)
- Vanadyl sulfate

Miscellaneous

Bromine (dark reddish-brown)
Chloroplatinic acid (red-brown)
Naphthylamine (reddish)
Nitrogen dioxide/tetroxide (red-brown)
Sulfur chloride (amber-red)
Cobalt chloride (pink-red if hydrated or dissolved)
Cobalt sulfate (pink-red if hydrated or dissolved)
Oleic acid (Commercial product yellow-red)
Sodium sulfide (yellow-red)
Ferric chloride (yellow-brown)
Tannic acid (yellow-brown)
Phosphorus pentasulfide (yellowish)
Chlorine (greenish-yellow gas; amber liquid)
Ammonium ferrocyanide (yellow-green-blue)
Ferrous sulfate (yellow-green)
Nickel sulfate (yellow-green)
Ferric hydroxide (brown)
Glyconic acid (brown)
Molasses (dark brown-black)
Nickel chloride (brown-green)
Nitric oxide (turns brown in air)
Copper chloride (blue-green)
Phosphorus (yellow, or violet-red)
Potassium permanganate (purple)
Naphthenic acid (commercial product dark)

Category 9: Fumes

Acetyl bromide
Acrylic acid
Benzoyl chloride
Boranes
Chlorosulfonic acid
Formic acid
Hydrazine
Hydrofluoric acid
Nitric acid (fuming grade)
Phosgene (liquid)
Phosphorus oxychloride
Phosphorus trichloride
Sulfur chloride
Sulfuric acid (fuming grade)
Titanium tetrachloride

Category 10: Vigorous reaction

Acetyl bromide
Antimony trichloride (white sediment)
Benzoyl chloride
Boranes
Calcium carbide
Calcium phosphide
Chlorosulfonic acid
Fluorine
Sodium (violent)
Sulfur chloride
Titanium tetrachloride (violent)

Category II: Odor-unpleasant

Irritant (stinging, choking sensation, rather than "smell")

- Acetyl bromide
- Acrylic acid (acrid)
- Ammonia (not unpleasant when dilute)
- Ammonium carbonate (not unpleasant when dilute)
- Benzoyl chloride
- Bromine
- Chlorine (not unpleasant when dilute)
- Chlorosulfonic acid
- Crotonaldehyde (acrid)
- Cyanogen bromide
- Cyanogen chloride
- Fluorine
- Formaldehyde (biting, characteristic)
- Formic acid
- Hydrochloric acid
- Hydrofluoric acid
- Methyl acrylate (acrid)
- Methylethyl pyridine
- Nitric acid
- Nitrogen dioxide/tetroxide
- Paraformaldehyde (biting, formaldehyde)
- Phosphorus oxychloride
- Phosphorus trichloride
- Propanal (suffocating)
- Quinone
- Quinoline (sharp, unpleasant)
- Sulfur chloride
- Sulfur dioxide (characteristic)
- Sulfurous acid (sulfur dioxide)
- Toluene diisocyanate

Sulfurous (rotten egg)

- Ammonium sulfide
- Phosphorus pentasulfide

Foul (other than sulfurous)

- Carbon disulfide (commercial grades)
- Methanethiol
- Thioglycolic acid

Miscellaneous

Allyl chloride (sweetish)
Butyl mercaptan (skunk)
Calcium carbide (impure acetylene)
Calcium phosphide (decaying fish)
Naphthylamine
Phenylcarbylamine chloride (onion)
Pyridine (nauseating)

Category 12: Odor-not unpleasant

Almond (both sweet and bitter)

- Benzoic acid
- Benzonitrile
- Chlorobenzene
- Furfural
- Hydrocyanic acid
- Nitrobenzene
- Potassium cyanide
- Salicylaldehyde

Ammoniacal (ammonia and amines)

- Amino ethyl ethanol amine
- Ammonia
- Ammonium carbonate
- Butylamine
- Diaminoethane
- Diethanolamine
- Diethylamine
- Diisopropanolamine
- Diisopropylamine
- Dimethylamine
- Ethylamine
- Ethyleneimine
- Methylamine
- Monoethanolamine
- Monoisopropanolamine
- Propylamine
- Triethanolamine
- Triethylamine
- Trimethylamine

Benzene (aromatic hydrocarbon)

- Benzene
- Ethyl benzene
- Styrene
- Toluene
- Xylene

Fragrant (fruity, flowery)

Acetaldehyde
Acetophenone
n-Amyl alcohol
n-Butyl acetate
Butyl alcohol
Methyl acetate
Pentanal
Polyglycol ether

Lysol (phenolic)

Cresol
Phenol
Trichlorophenol

Miscellaneous

Acetic acid (vinegar)
Acetic anhydride (vinegar)
Ammonium acetate (vinegar)
Acetonitrile (ether)
Dichloromethane (ether)
Propylene glycol (ether)
Acrylonitrile (biting)
Calcium hypochlorite (biting - chlorine)
Chlorine (clean biting odor when dilute)
Hypochlorous acid (chlorine)
Propanoic acid (sharp)
Propanoic anhydride (sharp)
Allyl chloride (mustard)
Mustard gas (mustard/onion)
Chloroform (sweetish)
Cyclohexane (sweetish)
Dichloroethane (sweetish)
Dichloropropane (sweetish)
Epichlorohydrin (sweetish)
Ethylene glycol (sweetish)
Lead tetraethyl (sweetish)
Ethyl alcohol (alcoholic, but often denatured)
Methyl alcohol (alcoholic, but often denatured)
Propyl alcohol (alcoholic)

Miscellaneous (continued)

Dichlorobenzene (mothball)
Naphthalene (mothball)
Methylisobutyl ketone (camphor)
Octyl alcohol (penetrating, pleasant)
Pentane (pleasant)
Acetamide (mousy)
Aniline (characteristic)
Carbon tetrachloride (cleaning fluid)
Phosgene (CAUTION: toxic concentration NOT strongly irritant)
Sodium sulfite (sulfurous)
Naphthenic acid (commercial grades may be offensive)

Category 11: Lacrimatory

NOTE that many other substances induce eye watering in high concentration.

Acetyl bromide
Allyl alcohol
Allyl chloride
Ammonia
Benzoyl chloride
Crotonaldehyde
Ethyl acrylate

Category 14: Flammable

Highly flammable

Acetaldehyde
Acetic anhydride
Acetonitrile
Acetylene
Acrylonitrile
Allyl chloride
Benzene
Butyl mercaptan
Carbon disulfide
Carbon monoxide
Chlorobutadiene
Crotonaldehyde
Cyclohexane
Diethylamine
Dimethylamine
Ethyl acrylate
Ethyl alcohol
Ethylamine
Ethylene
Ethyleneimine
Isoprene
Methanethiol
Methanol
Methylamine
Methyl methacrylate
Pentane
Pentene
Petroleum products, light
Phosphorus (yellow)
Propanal
Triethylamine
Vinyl acetate
Vinyl bromide
Vinyl chloride

Less flammable

n-Amyl acetate
Benzonitrile
Benzylamine
n-Butyl acetate
Butyl alcohol
Butylamine
Chlorobenzene
Diaminoethane
Dichloroethane
Dichloropropane
Diisopropylamine
Dimethyl sulfoxide
Ethyl benzene
Ethylene glycol
Ethylene glycol diacetate
Heptanol
Hexanol
Methyl acetate
Methyl acrylate
Methylethyl pyridine
Methylisobutyl ketone
Monoethanolamine
Monoisopropanolamine
Nitrobenzene
Nitropropane
Octyl alcohol
Oxydipropionitrile
Pentanal
Pentanol
Petroleum, crude, and heavy and medium products
Propanoic acid
Propanoic anhydride
Propyl alcohol
Propylamine
Propylene glycol
Propylene oxide
Styrene
Tetraethylene pentamine
Toluene
Triethanolamine
Xylene

Category 15: Acid

Dilute solution (or hydrolysis products) acid to litmus.

Acetic acid
Acetic anhydride
Acetyl bromide
Aluminum sulfate
Ammonium acetate
Benzoyl chloride
Chlorosulfonic acid
Chlorous acid
Fluorine
Formic acid
Hydrochloric acid
Hydrofluoric acid
Lactic acid
Nitrous acid
Oxalic acid
Phosphoric acid
Phosphorus oxychloride
Phosphorus pentasulfide
Phosphorus trichloride
Sodium bisulfite
Salicylic acid
Sulfur chloride
Sulfur dioxide
Sulfuric acid
Sulfurous acid
Thioglycolic acid
Zinc chloride
Zinc nitrate
Zinc sulfate
Zirconium sulfate

Category 16: Alkaline

Dilute solution (or products of reaction) alkaline to litmus.

Alkyl aryl ammonium halides
Ammonia
Barium hydroxide
Benzylamine
Diaminoethane
Diethanolamine
Diethylamine
Dimethylamine
Ethylamine
Ethyleneimine
Hydroxylamine
Potassium hydroxide
Propylamine
Sodium sulfide
Sodium stearate
Sodium silicate
Sodium oleate
Sodium methylate
Sodium hydroxide
Sodium hydrosulfide
Sodium cyanide
Sodium
Pyrocatechol
Pyrogallol
Triethanolamine
Triethylamine
Trimethylamine

Froth

- Alkyl aryl ammonium halides
- Anionic surfactants
- Linoleic acid
- Neutral surfactants
- Quaternary ammonium salts
- Sodium oleate
- Sodium palmitate
- Sodium stearate

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